SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JUNE 1901.

GENERAL PHYSICS.

1022. *Mechanical Properties of Caoutchouc.* **M. Cantone** and **G. Contino.** (N. Cimento, 12. pp. 242–257, 1900. Rend. R. Istit. Lombardo di sc. e lett. 31. p. 1521, 1898.)—The authors study the influence of traction and torsion on caoutchouc, and add some notes on its thermal expansion. The samples were of the red variety prepared by Pirelli & Co. It appears that as the load increases there is an increase in the modulus, and not a diminution as postulated by Villari and Röntgen. This is opposed to the behaviour of the metals. As regards torsion, the material behaves in essentially the same manner as do the hard metals. E. E. F.

1023. *Compressed-Air Manometer.* **S. Lussana.** (N. Cimento, 12. pp. 237–241, 1900.)—The manometer consists of an iron tube with air-tight caps, along the axis of which a platinum wire is stretched. The pressure to be measured forces mercury into the tube, and this compresses the air contained in the tube. The extent to which the mercury rises in the tube is measured by the length of the platinum wire submerged, and this again is measured by determining the resistance of the unsubmerged wire. The manometer may be used for pressures varying from 1 to 600 atmospheres. E. E. F.

1024. *Centrifugal Laboratory-Pump.* **E. Jordis.** (Zeitschr. Elektrochem. 7. pp. 464–466, Feb. 14, 1901.)—Specially designed for the determination of potential differences in electrolytes circulating at a constant speed. It is a centrifugal pump, consisting of a suction and a compression chamber, built up entirely of glass and rubber without any valves; the steel shaft is protected by a glass tube. The pump is made by Bender and Hobein, of Munich, and resembles the electrolyser of Wehrlin. When the supply and return pipes are coiled, the pump may be used as a thermostat, as it easily maintains a constant temperature.

Experiments show that the influence of the rate of circulation of an electrolyte ceases when a certain speed is exceeded. H. B.

1025. *Electrical Absorption Dynamometer.* **E. H. Rieter.** (Elektrotechn. Zeitschr. 22. pp. 194–196, Feb. 28, 1901.)—An illustrated description of an electrical absorption dynamometer consisting of an electromagnet provided with a single exciting coil and pole-pieces of alternate polarity curving back over the coil. The electromagnet is movable through a limited range about its axis. Surrounding the two crowns of pole-pieces is an iron or steel ring furnished with numerous thin ridges for carrying off the heat. The ring is coupled to the motor under test. The electromagnet carries two levers, one of which is graduated and fitted with a sliding weight, while the other is arranged to take heavier weights occupying one fixed position, exact balance being obtained by means of the sliding weight. A. H.

1026. *Viscosity of Solids.* **R. Reiger.** (Phys. Zeitschr. 2. pp. 213–217, Jan. 5, 1901.)—The author studies the "time of relaxation" in colophonium, gelatine, and chilled glass. He finds that in their plastic state these substances show a relaxation in accordance with Maxwell's theory, whereas in the hard state the viscosity rises first to a maximum before relaxation sets in. With falling temperatures the time of relaxation and the viscosity increase rapidly. A regular relaxation is only found within the range of validity of Hooke's law. After the maximum tension is attained in dried gelatine the relaxation sets in rapidly at first, and then very much more slowly. E. E. F.

1027. *Passage of Gases through Capillary Tubes.* **A. Job.** (Soc. Franç. Phys., Bull. 157. p. 2, 1901.)—The author describes a method of measuring the resistance offered by capillary tubes to the flow of gases; a voltameter is provided with a capillary tube outlet. The pressure produced in the voltameter, for a given current, measures the resistance of the capillary tube. The author suggests the application of this method to various experiments connected with the flow of gases. G. H. B.

1028. *Deformation of Solids.* **A. Mesnager.** (International Physical Congress at Paris, Report, 1. pp. 348–362, 1900.)—An isotropic solid subjected to force is elastically deformed according to the laws of the theory of elasticity if the principal forces at every point are such that—

$$\gamma > \frac{\nu_3}{1-\eta} - (\nu_1 + \nu_2 + \nu_3)\frac{\eta}{1+\eta}, \text{ .... } (1)$$

and—

$$\delta > \frac{\nu_3 + \nu_1}{2}\,\frac{1-2\eta}{1-\eta}\tan\psi + \frac{\nu_3 - \nu_1}{2(1-\eta)}\,\frac{1}{\cos\psi}, \text{ ...... } (2)$$

where γ is the cohesion (measured by breaking strains); $\nu_3 > \nu_2 > \nu_1$, the principal tensions; η the ratio of elongation to lateral contraction in simple traction; δ the hardness; $\tan\psi$ the coefficient of internal friction, which appears to be constant; $\psi = 2a - \frac{\pi}{4}$, a being the angle between Hartmann's lines and the direction of simple traction. If condition (2) be satisfied, but not (1), the body breaks without preliminary permanent deformation, like glass for example; if the converse hold good, there is a permanent deformation; δ increases in general with the deformation, and consequently the deformation is limited and uniform. If δ decreases, there may be rupture by sliding. In order to predict the slow deformations of an isotropic solid at a given temperature, it is necessary to know γ, a, and δ. Experimental methods are described for tracing the distribution of the resultant forces in glass and the variations of thickness, by means of double refraction; and examples are worked out. In permanent deformations the volume remains the same. In deformation beyond the limit of elasticity, if the stress be somewhat relieved the strain is relieved in an elastic manner, the coefficient of elasticity being in this case the same as that below the limit of elasticity; on the stress being restored the strain is also restored; and on the strain being further increased the stress goes on to a maximum. Beyond this maximum, in the case of traction, striction begins and goes on until rupture takes place. The resistance per unit of area increases constantly during the traction, even during the period of striction. Permanent deformation is due to sliding movement along planes at a fixed angle to the direction of traction. A. D.

1029. *Energy Accelerations.* **G. H. Bryan.** (Archives Néerlandaises, 5. pp. 279-294, 1900.)—The author defines as *energy accelerations* the second differential coefficients with respect to time of the squares and products of the velocities which enter into the expression for the kinetic energy of a system. He suggests a method of determining the distribution of velocities needed for the state of a system to be stationary when the probability that its co-ordinates lie between assigned limits is given. This consists in equating to zero the mean values of the energy accelerations and investigating the resulting conditions, which are called the *equations of energy equilibrium.* The conditions of stability are obtained by assuming that the mean values of the energy accelerations differ from their equilibrium values by harmonic functions of the time of period $2\pi/p$, forming therefrom the equation for determining p^2, and finding the conditions that this equation has real roots. The mean values are found on the assumption that the proper measure of the probable distribution of the co-ordinates of a system does not depend on the motions of the molecules and remains independent of the time so long as the energy and controllable co-ordinates of the system are constant. The investigation is complicated except in the simplest cases, as for n molecules, each with 3 degrees of freedom, there are $3n(3n+1)/2$ energy accelerations to consider. The author discusses three cases:—(1) When a single particle moves rectilinearly in a field of force; (2) when two attracting or repelling particles move in a straight line in a field of force; (3) when a single particle moves in any field of force in a plane. He finds that Maxwell's law of the partition of energy holds good in case (1), and in case (2) if the field of force vanishes; but not generally otherwise.

The advantage of this method is that it enables us to account for irreversible phenomena in a system the elements of which satisfy the equations of reversible dynamics; for the direction of transference of energy between two systems will depend on the sign of an inequality which involves only squares and products of velocities, so that the sign is unchanged by the reversal of all the velocities of the systems.

The liquefaction of a gas or the solidification of a liquid, by the passage of energy in the form of latent heat from the portion of the substance in the lower state to that in the higher, may be explained from the general properties of unstable equilibrium; and as instability may also lead to an increase in the mean kinetic energy of a system at the expense of its potential energy, or *vice versâ*, certain chemical phenomena may find a kinetic interpretation.

R. E. B.

1030. *Units.* **C. E. Guillaume.** (International Physical Congress at Paris, Report, 1. pp. 78-100, 1900.)—In the first part of the paper the author gives a *résumé* of the work done by the Commissions of 1872 and 1887 in establishing standards and definitions of the metre, the kilogramme, the litre, the international ohm, and the ampere and volt, and deals briefly with the photometric standards adopted in 1884 and 1896. In the second part the author discusses the various quantities, the units of which have not yet been standardised. As regards the unit of pressure, the Commission delegated by the Société de Physique has recommended the pressure of a column of mercury 75 cm. long, at 0° and at sea-level at latitude 45°; this pressure is equal to one megadyne per square cm. within 1 part in 15,000, and the proposed name is a "*barye*." Since Stefan's law has been experimentally confirmed for a black body, the author proposes as a measure of emissive power, the coefficient, which, multiplied by the surface of the radiating body in square cms. and by the fourth power of the absolute temperature, expressed in thousands of degrees Centigrade, gives in watts the value of the power radiated. The author discusses the possibility of determining a photometric standard in terms of the light emitted by a black body at a certain temperature, and criticises the proposed division of the spectrum into octaves, or regions comprised between two wave-lengths, one double the other. The paper concludes with a note on the latest determinations of the densities of water and of mercury. For the former, at 4° C., the author considers the figure 0·999955 correct to within two units in the fifth place, and for the latter, the figure 13·5950 correct to within three or four units in the fourth decimal place.

G. H. B.

1031. *Motion of an Ether assumed to be Fluid.* **G. Mie.** (Phys. Zeitschr. 2. pp. 319–325, Feb. 23, 1901. Paper read before the Naturforscherversammlung zu Aachen.)—If ether be a fluid it must be set in motion by such processes as the discharge of condensers, &c., and there must then be loss of energy. The object of the writer is to consider, using Helmholtz's method, the existence or non-existence of such motions of ether. After referring to his controversy with Wien [see Abstracts Nos. 484 and 485 (1901)] he lays down three assumptions, following Helmholtz:—(1) The forces acting on ether are conservative forces, *i.e.*, have a single valued potential. (2) The ether in its motion presents the properties of a frictionless incompressible fluid. (3) The energy of a particle of ether is the sum of three parts—electric, magnetic, and stream energy.

Of these assumptions (2) and (3) are not fulfilled by Kelvin's rotational ether or Sommerfeld's ether.

Let μ denote the mass per unit volume; α, β, γ, the component velocities of the fluid; and let

$$\frac{d\gamma}{dy}-\frac{d\beta}{dz}=x', \quad \frac{d\alpha}{dz}-\frac{d\gamma}{dx}=y', \quad \frac{d\beta}{dx}-\frac{d\alpha}{dy}=z':$$

also let u, v, w, be the components of Poynting's vector, and $\xi=\frac{dw}{dy}-\frac{dv}{dz}$, &c.

Then the author obtains by Helmholtz's method three equations:—

$$\mu x' = A^2\xi + a$$
$$\mu y' = A^2\eta + b$$
$$\mu z' = A^2\zeta + c$$

Here a, b, c are the components of a vortex, the lines of which form a vortex tube according to Helmholtz's well-known theorem. For this vortex only two assumptions are possible. Either (1) these vortices fill the ether in regular order, as discussed by Kelvin in Phil. Mag. 1887, in which case the ether must have properties differing from those of ordinary fluids; or (2) $a=b=c=0$.

In order to agree with assumption (2) the author chooses the second alternative. Hence it follows that the vortex lines in the motion of pure ether coincide with the vortex lines of Poynting's vector.

The author then makes two further assumptions :—(3) Ether is not only incompressible, but also of unlimited cohesion. (4) Molecules of bodies are completely penetrable by ether.

Following on this assumption, atoms are singular points, *i.e.*, origins of electric stress, in ether, and ether freely passes through them without carrying them with it in its own motion. If at first sight this presents a difficulty it is sufficient to suppose, he says, that the singular point which is the nucleus of the atom, is infinitely small compared with the distance between two centres.

The author applies his theory to several cases on the assumption that the variation of the field in the immediate neighbourhood of an atom due to the ether motion is to be neglected. If, however, we consider spaces of smaller than molecular dimensions this can no longer be done. It appears, he says, that in that case the presence of the atom, even though it be freely penetrable by ether, has an effect on the ether current; and he proposes to consider in a future paper the modification which will on this account be necessary in his equations. S. H. B.

1032. *Vortex-Rings.* **R. W. Wood.** (Nature, 63. pp. 418–420, Feb. 28, 1901.)—Experimental apparatus described, for producing and photographing vortex-rings, wholly or only partially charged with smoke. Vortex-rings can be produced by driving the smoke through a cullendar or through stretched linen cloth. Two rings side by side, if rotating rapidly, will bounce apart; but if they are sluggish they will coalesce first into an oscillating dumb-bell and ultimately into a circular form. A. D.

1033. *Constant of Gravitation.* **C. V. Boys.** (International Physical Congress at Paris, Report, 3. pp. 306–349, 1900.)—In this Report the author gives a historical sketch of the different investigations made up to the present time to find the value of the mean density of the earth and the gravitational constant. The various laboratory methods that have been adopted are described, and their difficulties discussed from the point of view of the practical experimenter. The following are the values found for Δ, the mean density of the earth, by the author and other recent experimenters :—

	Δ
Boys	5·527
Braun	5·52700 ± 0·0014 5·52725 ± 0·0012
Eötvös	5·55 ± 0·01
König, Richarz, and Krigar-Menzel	5·505.

W. C. H.

1034. *Variation of Gravity over the Surface of the Earth.* **R. Bourgeois.** (International Physical Congress at Paris, Report, 3. pp. 350–370, 1900.)—In the first part of this Report, the author gives a short sketch of the various pendulum experiments from the time of Galileo up to the present time, tracing the gradual elimination of imperfections in the apparatus. In the second part the results of these experiments, giving values of *g* at different places on the earth's surface, are discussed. From all these results we ought to be able to calculate the variation of weight from the equator to the pole and so deduce the eccentricity of the earth by the formulæ of Clairaut and Laplace :—

$$\frac{g_p - g_{eq}}{g_{eq}} = \frac{5}{2}m - e = \frac{l_p - l_{eq}}{l_{eq}},$$

$$l\phi = l_{eq} + (l_p - l_{eq})\sin^2\phi,$$

where e is the eccentricity, ϕ the latitude, and m the ratio of equatorial centrifugal force to equatorial weight ($= \frac{1}{288}$). The author shows, however, that we have not yet sufficient results, and that those we have present too many anomalies and difficulties of various kinds to allow of comparison with one another. W. C. H.

1035. *Rotation of a Body partly Solid and partly Fluid.* **G. de Prato.** (N. Cimento, 5. pp. 41–50, Jan., 1901.)—A study of the equations of motion of a system of points, of material partly solid and partly fluid, in which the motions are such as to leave the distribution of matter unchanged, this result being due to the mutual action of the various points, under a gravitation law, with special reference to the earth considered as such a system. A. D.

1036. *Anomalous Dispersion and Spectrum of Chromosphere.* **R. W. Wood.** (Astrophys. Journ. 13. pp. 63–67, Jan., 1900.)—Acting on a suggestion put forward by W. H. Julius [see Abstract No. 33 (1901)] that the "flash" spectrum seen immediately at totality may be due to photospheric light abnormally refracted, the author has been successful in devising an experiment whereby such a line spectrum may be produced in the laboratory, *i.e.*, he has been able to see a spectrum of bright lines with light from a source showing a continuous spectrum, by means of causing it to suffer anomalous dispersion in an incandescent metallic vapour. The theory of Julius assumes the sun surrounded by an atmosphere of metallic vapours, whose density and refractive index decrease with increasing distance from the surface. The refractive index for any ray will be small except for wave-lengths near those which are absorbed by the vapour, so that the light most strongly refracted will be that closely resembling the rays emitted by the metallic vapours. The graduated layers of vapour were obtained by allowing the flame of a Bunsen burner fed with metallic sodium to play on the under surface of a white plaster plate. A narrow dark space is seen to exist between the flame and plate. The edge of the flame was then illuminated by sunlight from a large mirror, the white light thus emitted corresponding to the photospheric radiation. This was examined by a telescope with a direct vision objective prism, adjusted until the Fraunhofer lines were visible. On placing fresh sodium in the Bunsen flame the solar spectrum vanished, and was replaced by two bright lines in the place of the previous dark sodium lines. These at once disappeared if the sunlight was cut off. Repetition of the experiment showed that the places of the flash bright lines were slightly more refrangible than the original dark ones.

Further experiments showed that abnormally dispersed light was also to be detected on the red side of the normal lines. Good results have been obtained with potassium and thallium, and it is hoped to obtain similar spectra with light sources of more complicated constitution, and more precise determinations of the refractivity of metallic vapours are being obtained by the use of a hollow metal prism with mica windows. C. P. B.

1037. *Nature of Solar Corona.* **R. W. Wood.** (Astrophys. Journ. 13. pp. 68–79, Jan., 1901.)—This paper consists of a suggestive discussion of the facts brought forward by the work done at the last few eclipses, and indicates the lines along which future research might profitably extend. The presence of polarised light in the spectrum must be taken as a positive proof of the existence of minute solid particles, as under no conditions known to the author has an electrically excited gas been found to emit polarised light. As to the absence of the Fraunhofer lines making it doubtful if the light is reflected sunlight, it may be that the oblique prism faces are such as to stop the polarised light. A method suggested for eliminating this is to use a Nicol before the slit, which is set tangential to the solar image, in which case the polarised rays will be transmitted by the prism and the dark lines might thus be rendered visible.

Experiments are then described illustrating the reflection of light by flames, illustrated by several photographs. A case apparently closely resembling the conditions of the corona was obtained where the use of the Nicol did bring out the dark lines which were otherwise invisible. It also indicated that the flame reflects comparatively little of the red or orange rays, so that success would be most probable by examining the actinic part of the spectrum. This fact may account for the absence of heat radiations from the coronal spectrum, as determined during the last eclipses.

Some interesting experiments are also described bearing on the temperature to which the particles of the corona will be subjected from the direct photospheric radiations. Using a concave speculum of variable area, a temperature of 1,100° C. was obtained, copper being melted with ease. The remainder of the paper is occupied with a long and useful discussion of the bearing of these experiments on the nature of the corona. C. P. B.

1038. *Motion of the Solar System.* **W. W. Campbell.** (Astrophys. Journ. 13. pp. 80–89, Jan., 1901.)—Since the satisfactory adjustment of the Mills spectrograph at the Lick Observatory in 1896, Campbell has obtained some 2,000 spectrograms, 1,500 of which show satisfactory spectra of about 325 stars. It is not yet possible to give the detailed reductions for each star, but from 280 of them a determination of the motion of the solar system has been deduced. The observations were divided into groups, and the equations of condition and reduction are given. The elements of the solar motion thus determined are—

$$V = -19{\cdot}89 \text{ km.} \pm 1{\cdot}52 \text{ km.}$$
$$\text{R.A. of apex} = 277^\circ\ 30' \pm 4^\circ{\cdot}8$$
$$\text{Decl.}\ \ ,, \ = +\ 19^\circ\ 58' \pm 5^\circ{\cdot}9$$

Comparisons with the determinations of other observers, and the questions of spectroscopic binaries and relative motions of faint and bright stars occupy the remainder of the paper. C. P. B.

1039. *Formation of Hailstones.* **L. Bombicci.** (Elettricità, Milan, 20. pp. 34–37, Jan. 19, 1901.)—This paper is a discussion, with some criticisms of Artom's theory of the formation of hailstones [Abstract No. 345 (1901)]. The author does not think that hailstones can be formed by the rotation of frozen particles of water, on the point of crystallisation, but compares them with the spheroidal crystals of various minerals, which are formed in more or less solid media, where any rotatory motion would be impossible. He believes their formation to take place in a cold atmospheric region, saturated with

minute water crystals (generally electrified by friction with the air), when these come into contact with swarms of frozen amorphous granules; such swarms are formed in higher and colder layers by the rapid freezing of water-vapour contained in ascending columns of warm and damp air. The author also criticises Artom's theory of the action of hail-preventing cannons.
G. H. B.

REFERENCES.

1040. *Oscillations of Lakes.* **F. A. Forel** and **É. Sarasin.** (International Physical Congress at Paris, Report, 3. pp. 394–408, 1900.)

1041. *Ice and Glaciers.* **E. Hagenbach.** (International Physical Congress at Paris, Report, 3. pp. 409–414, 1900.)

1042. *Kinetic Theory of Planetary Atmospheres.* **G. H. Bryan.** (Roy. Soc., Phil. Trans. 196. pp. 1–24, Feb. 18, 1901.)—This paper was referred to in Abstract No. 37 (1901), but is here given in its complete form.

1043. *Atmospheres of the Earth and Planets.* **M. v. Smoluchowski.** (Phys. Zeitschr. 2. pp. 307–313, Feb. 16, 1901. Extract from a paper in a Jubilee Publication of the Lemberg University.)—This paper contains a very general discussion of the views which have been entertained regarding the diminution of temperature and density upwards in the atmosphere, and the existence of a limit to its extent. In the concluding portion the author expresses his disagreement with the views put forward by Johnstone Stoney.
A. E.

1044. *Mounting for Tube Containing Liquefied CO_2.* **E. H. Hall.** (Phys. Rev. 12. pp. 125–126, Feb., 1901.)—An arrangement is described for making the meniscus vanish and reappear by means of water at, say, 27° C.
A. D.

LIGHT.

1045. *Radiation of a Black Body.* **O. Lummer.** (International Physical Congress at Paris, Report, 2. pp. 41–99, 1900.)—This report contains a synopsis of most of the experimental work which has been done on the radiation of a black body, together with a critical review and comparison of the results of theory and experiment. The most important researches are those of Lummer and Pringsheim, Lummer and Kurlbaum, Rubens, Beckmann, Paschen, and Wanner. The law of Stefan,

$$S = \int_0^\infty E d\lambda = \sigma\theta^4,$$

and the displacement law of Wien,

$$\lambda_m\theta = \text{const.} = A,$$

have been proved both experimentally and theoretically. The third equation,

$$E_m\theta^{-5} = \text{const.} = B,$$

follows immediately from these two.

The various formulæ which have been deduced to express the partition of energy in the spectrum of a black body are all discussed, and the conclusion is come to that more experimental knowledge is required before any decision can be come to as to which of the formulæ actually represents the facts. These formulæ are given by the general formulæ of Lummer and Jahnke—

$$E = C\theta^{5-\mu}\lambda^{-\mu}e^{-\frac{c}{(\lambda\theta)^\nu}},$$

in which, if $\nu = 1$ and $\mu = 5$, we have Wien's formula; if $\nu = 1$ and $\mu = 4{\cdot}5$, we have that of Thiesen; and if $\nu = 1$ and $\mu = 4$, the formula is that of Rayleigh.

J. B. H.

1046. *Radiation and Draper's Law.* **O. Lummer.** (Archiv. Math. Phys. 1. pp. 77–90, 1901.)—This is the first of two papers in which the author is going to treat in a somewhat fuller manner the radiation problems which he dealt with in his address to the Paris Congress. The present paper deals with the supposed law, first propounded by Draper, that all bodies begin to emit light at the same temperature. After adversely criticising Draper's and Kirchhoff's conclusions drawn from their experiments on this point, the author gives a *résumé* of the more recent researches on the subject. The first sensation of light as the temperature of a body is gradually raised in a dark room is the "grey-glow," now known to be due to the rods in the retina, but this can scarcely be called emission of light, since the human eye cannot then bring the body to a focus, the attempt only serving to make the body invisible again. This is due to the distribution of the rods and cones in the human retina. The first real sensation of light takes place at a much higher temperature, which varies with the body emitting it, so that here Draper's law does not apply. Whether it applies to the "grey-glow" is very doubtful. The author has observed the grey-glow as low as 360° C.

J. B. H.

1047. *Radiation of a Black Body.* **C. E. Mendenhall** and **F. A. Saunders.** (Astrophys. Journ. 13. pp. 25–47, Jan., 1901.)—This paper starts with a short *résumé* in tabular form of the various so-called "laws" which have been obtained (for the most part theoretically) for the radiation of a black body, and which have lately been put to test by experiment. Some experiments which the authors have carried out with the same object are then described. These experiments have led to rather inconclusive results owing to the great experimental difficulties, and the authors conclude that no results of sufficient accuracy can be obtained without taking excessive precautions in regard to the "blackness" of both radiator and bolometer strips, and in excluding from the air about the apparatus all traces of carbon dioxide and water vapour. The experimental difficulties are fully dealt with. J. B. H.

1048. *Radiation of Black Bodies.* **C. E. Guillaume.** (Ind. Élect. 10. pp. 101–103, March 10, 1901.)—The radiation of a black (hollow) body is compared with that of platinum by means of Lummer and Kurlbaum's method. The author gives the following results, showing the relation between the absolute temperature θ, the brightness E of the black body, and the luminous output R—

θ	E	R
900	0·069	1·10
1,000	1·000	1·00
1,100	7·729	5·28
1,200	40·89	19·72
1,300	167·4	56·61
1,400	569·3	148·2
1,500	1,682	332·2
1,600	4,445	678·2
1,700	10,740	1,286
1,800	24,110	2,297
1,900	50,830	3,900
2,000	101,600	6,350

The efficiency is calculated on the basis of Stefan's law, according to which the total energy dissipated is proportional to the fourth power of the absolute temperature. E. E. F.

1049. *Radiation of a Black Body.* **F. Paschen.** (Ann. d. Physik, 4. 2. pp. 277–298, Feb., 1901.)—The investigations made by the author himself and Wanner showed the validity of Wien's law for a large range of comparatively small values of λT [see Abstract No. 1348 (1899)]. That law is expressed by—

$$J = c_1 \lambda^{-5} \epsilon^{-\frac{c_2}{\lambda T}},$$

where J is the energy of the radiation of wave-length λ and T is the absolute temperature. Further experiments have proved, however, that though Wien's law holds good for small values of λT, Thiessen's formula—

$$JT^{-5} = f(\lambda T)$$

agrees more closely with the experiments of Lummer-Pringsheim and Beckmann-Rubens. And at large values of λT Rayleigh's formula corresponds more closely with the values found by Rubens and Kurlbaum.

But the whole set of measurements available are really covered by Planck's new formula—

$$J = c_1\lambda^{-5}\frac{1}{e^{\frac{c_2}{\lambda T}} - 1}$$

and whereas c_2 is $5\lambda_m T$ in Wien's formula, it is $4·9651\ \lambda_m T$ in Planck's. The latter is completely verified over a range of $1/\lambda T$ extending from 0·002 to 0·00001. E. E. F.

1050. *Selective Reflection.* **F. Paschen.** (Ann. d. Physik, 4. 2. pp. 304–306, Feb., 1901.)—The tests of reflective power for various wave-lengths were carried out on one silver mirror freshly prepared and polished, one newly silvered glass plate, one old silvered glass plate, and a German-silver mirror. For a wave-length of 0·7786 μ the solid silver mirror showed a reflective power of 94·24 per cent., the two silver-on-glass mirrors 91.96 and 85·15 per cent. respectively, and the German-silver mirror 70·89 per cent. For a wave-length of 7·737 μ the corresponding figures were 98·69, 98·46, 96·17, and 94·03. E. E. F.

1051. *Refractivities of the Inactive Gases.* **W. Ramsay.** (Archives Néerlandaises, 5. pp. 356–359, 1900.)—Using the apparatus devised by Rayleigh for the refractivity of argon, the following values were found for the refractivities of this and the other inactive gases of the atmosphere—

Helium.	Neon.	Argon.	Krypton.	Xenon.
0·1238	0·2345	0·968	1·449	2·364

These numbers express the refractivities compared with air, and are proportional to $(\mu - 1)$. On division of these numbers by the densities of the gases, or by their atomic weights, a series of figures is obtained which expresses the retardation of light by equal quantities of matter. These quotients are respectively 0·0309, 0·0172, 0·0242, 0·0177, and 0·0184. Thus the quotients for helium and argon are high, while neon, krypton, and xenon yield almost the same numbers as each other. E. H. B.

1052. *Photographic Action of Dark Light.* **W. J. Russell.** (Roy. Inst., Proc. 16. pp. 140–146, 1900.)—This paper is a popular description of the action produced on photographic plates by various metals and organic substances, notably the turpenes and oils, and of the transparency of different substances to this radiation. G. H. B.

1053. *Preservation of Photographic Plates.* **C. Jones.** (Nature, 63. pp. 373–374, Feb. 14, 1901.)—The paper refers to Lockyer's article [Abstract No. 783 (1901)] in which gold toning is recommended as a means of preserving negatives of star photographs and other subjects, where it is of the utmost importance that the image should be absolutely permanent. The author deprecates the use of gold toning on the ground that the resulting deposit is of a complex character, and may be subject to changes which cannot be foreseen, and also because toning is an incomplete operation and does not produce a proportional change throughout the image, with the result that measurements of the effect of light are rendered of doubtful value. He proposes instead a more careful treatment of the silver image. Ammonia, potassium, cyanide, sodium thiosulphate, and ferric oxalate dissolve metallic silver in the presence of air; these should therefore be avoided as far as possible in the processes of development and fixing. Alkaline developers can replace ferrous oxalate, the ammonia can be replaced by sodium carbonate, and the thiosulphate should be removed by a prolonged washing. The author recommends a plentiful use of sodium sulphite in the developer to prevent the deposition of staining matter; acid clearing baths are injurious, they only lighten the colour of the stain and render it insoluble; alkaline baths have the opposite effect, and a little carbonate of soda or caustic soda may be added with advantage to the first wash waters. The film should be protected by varnish, preferably a celluloid varnish, the plate being heated previously to as high a temperature as the hand can bear to thoroughly dry the gelatine. A better protection is a cover-glass cemented on with Canada balsam. On no account should any printing paper be allowed to touch the unprotected film. So as not to rely entirely on the silver, platinum or carbon prints should be taken; the author considers platinum more trustworthy as to permanence. G. H. B.

1054. *Measuring the Curvature of a Reflecting Surface.* **R. Dongier.** (Soc. Franç. Phys., Bull. 161. pp. 3–4, 1901.)—The apparatus consists of a cross wire which is strongly illuminated by a light placed behind it; the light then falls on the surface under examination and is reflected through a lens, finally being brought to a focus and forming an image of the cross wires in the field of a microscope. The object under examination is placed on a movable platform, the extent of the movement of which can be easily observed. This instrument is said to give more accurate results than the spherometer. It is also applicable to the study of any optical system whatever, whether convergent or divergent. [A fuller account appears in the Journ. de Phys. 10. pp. 266–276, April, 1901.] W. C. O.

1055. *Sharpness of Sight.* **A. Broca.** (Soc. Franç. Phys., Bull. 159. p. 2, 1901.)—Sharpness of sight of unit value is defined by the analysis of detail in an object viewed under an apparent angle of 1′. Visual sharpness is augmented from 0·65 to about 0·81 by adaptation, when the illumination is about 1 candle-metre. The author studied the visual sharpness when the ratio I/I′ of illumination of closely adjoining patches varied. For values of I/I′ comprised between 0 and 0·08, adaptation produces no variation. From 0·08 to 0·15 the sharpness changes from 1·0 to 0·9. At 0·6 it falls abruptly when I is, say, 40 candle-metres. The curve of variation of visual sharpness as a function of the intensity for $I'/I = 0{\cdot}6$ shows that it begins to diminish at three or four times the intensity at which the decrease sets in for $I'/I = 0$. This explains the considerable effect of adaptation for seeing details in radioscopy. Studying by means of Masson's disc the effect of making I′/I tend towards the discernible limit, the author found that the sensibility increases until the patches are seen under an angle of 15′ to 20′. The decrease of sensibility is very slow between 15′ and 9′, and then becomes very rapid. E. E. F.

1056. *Interferometer Curves.* **J. C. Shedd.** (Phys. Rev. 11. pp. 304–315, 1900.)—The author describes several new operations with Michelson's refractometer. One of them is that of finding the chromatic fringes (zero position) without any previous acquaintance with the instrument. Having secured fringes with the sodium flame in the usual manner, the movable mirror is run out 6 or 7 mm. and adjusted to minimum parallax. This will give a small value to the angle between the fixed mirror and the reflection of the movable one. The latter is now advanced through the zero position until the curves are hyperbolæ. The motion is finally reversed and the movable mirror is allowed to recede until the fringes just begin to become circular. If, now, white light be substituted for the sodium flame, and the movable mirror be made to slowly recede by means of the tangent screw, chromatic fringes quickly appear. So distinct are they that the diffused light of the room is sufficient to bring them out very clearly. E. E. F.

1057. *Dispersion Formulæ.* **L. Gorczyński.** (Phys. Zeitschr. 2. pp. 205–211, Jan. 5, 1901.)—The author discusses the formulæ of Cauchy, Schmidt, Ketteler, Wüllner, Hartmann, and Lommel. The latter is the best for making up tables of dispersion, especially when extrapolation is required.
E. E. F.

1058. *Change of Form of Light Vibrations.* **W. Voigt.** (Ann. d. Physik, 4. 1. pp. 209–214, Jan., 1901.)—In a former paper [Abstract No. 1670 (1899)] on the propagation of plane waves of not quite periodic frequency in an infinite, absorbing and dispersing medium, the equation—

$$\frac{\partial^2 u}{\partial t^2} = a^2\frac{\partial^2 u}{\partial z^2} - 2b\frac{\partial u}{\partial t}$$

was established. In the integration of this equation an error had been made which the present note corrects. It is shown that the expression finally arrived at leads to the same results as before, viz., the beginning of a motion of the plane $z=0$ is propagated with the same velocity as if the medium were not an absorbing one: the end of the motion is not propagated at all, an after effect due to past excitation remaining and only disappearing after an infinitely long time, and the vibration form changes during propagation.
G. E. A.

1059. *Pressure of Light.* **P. Lebedef.** (International Physical Congress at Paris, Report, 2. 133–140, 1900.)—Maxwell's pressure in the ether, in a direction normal to the waves and numerically equal to the energy per unit of volume, and equal for bright sunlight to the weight of 0·4 mgr. per square metre of black absorbent surface and 0·8 mgr. per square metre of mirror, is experimentally demonstrated by a method designed to eliminate thermal and radiometric causes of error. There remains always a pressure which is, in amount, that predicted by the theory. Let such a pressure act upon the head of a comet; the larger stones would be little affected, those of smaller and smaller size down to 1 cm. would be more and more repelled by the pressure of the light, and the very fine dust would be repelled. The head of the comet would thus be spread out. A. D.

1060. *Investigating the Polarisation of Ultra-violet and other Light.* **W. Voigt.** (Phys. Zeitschr. 2. pp. 303–306, Feb. 16, 1901.)—The method is being used with satisfactory results in an investigation of optical constants of some of the metals. In addition to an analyser (Nicol, or plane mirror), two double wedges of quartz are required. The first of these consists of two equal wedges cut perpendicular to the optic axis, one from a right-handed, the other from a left-handed crystal. The second consists of two equal wedges cut *parallel* to the optic axis, and having their edges parallel and perpendicular respectively to the axis. The wedges of each pair are cemented together so as to form a plate. The two plates are placed one behind the other, the edges of the first pair of wedges being at right angles to those of the second pair. When the polarised light transmitted through the combination is observed with the analyser, a system of dark spots is seen, and these spots move along parallel lines when the analyser is revolved. It is found most convenient to use photography, small light spots appearing on the negative corresponding to the black spots above mentioned. Their rectangular coordinates can be measured with considerable accuracy, and the author explains how the state of polarisation of the incident light can be deduced from these co-ordinates. By using quartz lenses with Nicol prisms, the method can be applied nearly as far as wave-length 0·3 μ. The greater portion of the paper is occupied by a mathematical discussion, and the writer announces that a more extended account will be published elsewhere.

A. E.

1061. *Action of Salts upon Rotatory Power of Sugars.* **J. de Kowalski** and **P. Tomartschenko.** (Archives des Sciences, 11. pp. 294–299, March, 1901.)—In general the rotatory power of saccharose diminishes in presence of halogen salts, the more so as the concentration of the salt increases. The amount of the diminution and the molecular weight of the salt are related, but are not, as Farnsteiner thought, inversely proportional to one another. The diminution of rotatory power produced by a salt is greater the less dissociated the salt, and the power of producing such diminution is greater the less the power of dissociating. NaCl, KCl, and LiCl produce an increase of the lævo-rotatory power of invert sugar. The dextro-rotatory power of glycose is diminished by salts, but to a smaller extent than in the case of saccharose. In glucose bi-rotation may be eliminated by adding a drop of a very weak solution of ammonia and heating the solution for some hours to 65°.

A. D.

1062. *Influence of Solvents on the Rotation of Optically Active Compounds.* **T. S. Patterson.** (Chem. Soc., Journ. 79. and 80. pp. 167–216, Feb., and pp. 477–493, April, 1901.)—Part I. *Influence of Water, Methyl-, Ethyl-, and n-Propyl-Alcohols, and Glycerol on the Rotatory Power of Ethyl Tartrate.*—The author gives the results of a large number of experiments made to determine the influence of the above-named solvents on the rotation of ethyl tartrate at various concentrations and temperatures. From the numbers obtained curves have been constructed showing for each solvent the connection between (1) the specific rotation of the ester and the temperature for solutions of different concentrations, and (2) the specific rotation and the concentration at 20°. In dilute solutions the solvent exerts its greatest influence, and in these a gradual variation is found to occur (1) in the value of the specific rotation, which decreases as the molecular weight of the solvent increases; (2) in the form of the rotation-concentration curves, those for water and methyl alcohol being concave towards the axis of concentration while in the case of ethyl alcohol there is a slight convexity which is more marked for propyl alcohol and still more so for glycerol; (3) in the effect of increase of temperature upon corresponding solutions. In water the temperature coefficient of the rotation is negative, in methyl alcohol positive and slightly less than for the pure ester, in ethyl alcohol the same as for the pure ester, whilst for *n*-propyl alcohol it has a distinctly higher value. The author then discusses the results with a view to correlating the variation in rotation with some similarly variable physical property of the dissolved substance, the solvent or the solution. He suggests that the requirements of such a property are met by what is known as the "internal pressure" of the solvent. The data obtained by the author render possible the calculation of the molecular solution volume (M.S.V.) between which and the rotation a regularity is found to exist, the variation of rotation with change of temperature being readily explained by certain assumptions regarding the way in which the asymmetry of the molecule changes with change of its volume. Connection is then traced between the rotation and the internal pressure or, what is probably the same thing, the heat of disgregation, and in this case also regularities are found to exist, indicating that the assumptions made as to the dependence of solution volume on internal pressure and of rotation on both of these, are justified. The following table contains a summary of the relationships discussed by the author :—

Solvent.	$[\alpha]_D^{20°}$ Infinite Dilution.	Association Factor of Solvent.		M.S.V. of Ethyl Tartrate. Infinite Dilution, 20°.	Heat of Disgregation of Solvent, 60°.	Dielectric Constant of Solvent.
		Ramsay and Shields.	Traube 15°.			
Water	+ 26·2°	1·644 (20°)	2·3	157·7	523·1	80
Methyl alcohol..	11·5	2·32 (20°)	1·79	159·3	248·6	32
Glycerol	10·6	—	1·90	163·3	—	56·2
Ethyl alcohol ...	9·1	1·65 (20°)	1·67	164	201·6	26·1
n-Propyl alcohol	7·4	2·25 (46·3°)	1·66	167·5	175·2	22

Part II. *Influence of iso-Butyl Alcohol and sec-Octyl Alcohol* (*Methylhexylcarbinol*) *on Ethyl Tartrate.*—Measurements of the rotation of ethyl tartrate in iso-butyl and sec-octyl alcohols show that the rotation continues to diminish as the molecular weight of the solvent increases. As will be seen from the numbers given in the following table, which refer to 20°, the molecular solution volumes obtained with these solvents confirm the results obtained with the lower alcohols ; so long as the diminution of rotation continues in passing from one solvent to another, so long also does the molecular solution volume increase and the decrements of rotation correspond fairly closely with the increments of volume.

Solvent.	M.S.V. Infinite Dilution.	Δ	$[\alpha]_D$ Infinite Dilution.	Δ	Change in $[\alpha]_D$ due to Solution.
Methyl alcohol	159·3 c.c.		11·50°		3·84°
Ethyl „	164·0	4·7 c.c.	9·13	2·37°	1·47
n-Propyl „	167·5	3·5 c.c.	7·40	1·78	— 0·26
iso-Butyl „	170·3	2·8 c.c.	6·53	0·87	— 1·23
sec-Octyl „	174·3	4·0 c.c.	5·24	1·29	— 2·52

It will also be noticed that the changes in volume and rotation appear to become simultaneously smaller and probably both tend to limiting values, which are, however, not the constants for free ethyl tartrate. T. H. P.

1063. *Magnetic Optical Dispersion in Negatively Rotating Salt Solutions: Potassium Ferricyanide.* **L. H. Siertsema.** (Archives Néerlandaises, **5.** pp. 447–452, 1900.)—In the case of titanium chloride and ferric chloride solutions, which deviate from the general rule stating that the magnetic rotation of the plane of polarisation is in the same sense as the magnetising current, it has been shown by Becquerel that the amount of their negative rotation is proportional not to $1/\lambda^2$, but to $1/\lambda^4$. The author gives results of a number of measurements of the dispersions, for different pairs of wave-lengths, of the magnetic rotation of a solution of potassium ferricyanide containing 1 gramme of salt per 100 grammes of solution; the numbers show that the dispersion is much greater than would correspond with proportionality between the rotation and $1/\lambda^4$. T. H. P.

1064. *Optical Constants of Quartz.* **J. M. de Lépinay.** (Journ. de Physique, 9. pp. 644–652, 1900.)—The author has applied [illegible] half-shadow analyser [see Abstract No. 789 (1901)] to the determination of the characteristic constants of the rotatory power and birefrangence of quartz for the green ray of mercury of wave-length 0·54607424 μ. The rotatory power of quartz, 1 cm. thick, at 0° is—

$$\alpha = 255{\cdot}171^\circ + 0{\cdot}0046\,(t - 15^\circ).$$

The new and accurate figures obtained make Mouton's method of measuring thicknesses reliable and convenient. E. E. F.

1065. *Theories and Formulæ of Dispersion.* **E. Carvallo.** (International Physical Congress at Paris, Report, 2. pp. 175-199, 1900.)—An historical sketch is given including the theories of Cauchy, Briot, Boussinesq, Sellmeier O. E. Meyer, Helmholtz, Lommel, Ketteler, and Poincaré. Near the end of the paper the author proposes the new formula,

$$n^2 = \gamma'\lambda^4 + \gamma\lambda^2 + \alpha + \frac{\beta}{\lambda^2} + \beta'\frac{n^2}{\lambda^2},$$

where λ denotes wave-length in vacuo, n index of refraction, and the other quantities represent constants. A. E.

1066. *Interferometer Study of Zeeman Effect.* **J. C. Shedd.** (Phys. Zeitschr. 2. pp. 278–283, Feb. 9, 1901.)—The author gives an account of his study of the Zeeman effect by means of Michelson's interferometer. His method depends upon drawing the "visibility" curves, taking for ordinate the intensity of the fringes and for abscissa the difference of path of the interfering rays (Michelson, Phil. Mag. 13. 338, 1891), and he shows how, by means of these, the broadening, multiplication and polarisation of the lines can be studied. He gives four methods for the measurement of the change of wave-length, the second alone being applicable for observations perpendicular to the direction of the magnetic field. In the first method, used by Michelson which is a good one if the difference of wave-length is not very small, the distance between two successive maxima in the curve is measured. In the second, when observation is made perpendicular to the direction of the magnetic force, the middle component is cut out by a Nicol prism and the position sought such that the systems of fringes arising from the two other components touch one another. In the third method one of the systems is extinguished and a position obtained such that the centre of the field is dark or bright according as the magnetic field is not or is excited. In the fourth method a position is obtained such that a given line is tangential to each set of fringes when the other is cut off. The author, in conclusion, compares the determined breadth of the equivalent simple light sources with the differences of wave-length, and claims to obtain results which are satisfactory and which confirm the validity of the methods employed. [See further Abstract No. 625 (1900).] W. E. T.

1067. *Dispersion of Fluorspar.* **F. Paschen.** (Ann. d. Physik, 4. 2. pp. 299–303, Feb., 1901.)—Measurements of the dispersion of fluorspar in the infra-red were made in order to test the usefulness of Ketteler's formulæ. The range of wave-lengths extended from $\lambda = 0{\cdot}8840\,\mu$ to $7{\cdot}0718\,\mu$. The formula agreeing best with the results was—

$$n^2 = A^2 - \frac{M_2}{\lambda^2 - \lambda_2^2} - k\lambda^2 - h\lambda^4,$$

with $A^2 = 2{\cdot}03913$, $k = 0{\cdot}0032055$, $n = 0{\cdot}000002894$, $M_2 = 0{\cdot}006125$, and $\lambda_2^2 = 0{\cdot}008884$. E. E. F.

1068. *Unsymmetric Alteration of Spectrum Lines in a Magnetic Field.* **P. Zeeman.** (Archives Néerlandaises, 5. pp. 237–241, 1900.)—The author was able to compare more closely the effects on light of magnetic fields of different strengths by employing an extended source of light, whose different parts were subject to different magnetic forces. In order to avoid the astigmatism of the image in Rowland's apparatus, he made use of the arrangement of Runge and Paschen [Abstract No. 24 (1898)], in which he shows that the observer looking along the normal to the grating obtains a stigmatic image. This involved, however, focussing afresh for each part of the spectrum. He believes that he could observe directly a difference in the intensity of the outer components of the D_1 line in the direction required by theory (Voigt, Drude's Annalen, 1. p. 376, 1900). Removing by a Nicol the central components of the blue and green zinc and cadmium lines, he could observe directly the want of symmetry in the intensity of the remaining components. W. E. T.

1069. *Spark Spectrum of Silicon.* **W. N. Hartley.** (Roy. Soc., Proc. 68. pp. 109–112, March 25, 1901.)—This paper is in answer to a remark by Lunt that the early work of Hartley and Adeney, and Eder and Valenta only referred to the more refrangible portions of the spectrum. Reference to the 1883 photographs shows that the least refrangible line of silicon is at λ2881·0, and no trace of any between λλ4573 — 4553, where the triplet occurs as found by Lunt.

Some remarks are also made on the interaction of the other substances present in influencing the relative intensity of the sodium and carbon lines found on the plates. C. P. B.

1070. *Radiation of Gases.* **E. Pringsheim.** (International Physical Congress at Paris, Report, 2. pp. 100–132, 1900.)—This address contains a review of the literature on the emission and absorption of gases. The conclusions arrived at are the following :—

(1) True calorific radiation (where the conditions of Kirchhoff's law are completely fulfilled) very probably takes place in the continuous spectra and the band spectra of gases and vapours, which emit these spectra at high temperatures, such as H_2O, CO_2, I, Br, Cl, S, Se, As, Na, K, Li, Tl. (2) When these continuous and band spectra emanate from flames the emission is partly due to chemical transformations, and consequently Kirchhoff's law does not apply. (3) Kirchhoff's law does not apply to the line and band

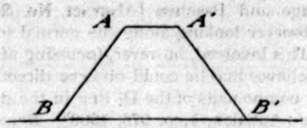
spectra of fluorescent gases. (4) The same is the case for spectra produced by the electric discharge. These owe their origin not to the high temperature but to electric phenomena, and possibly to complicated chemical transformations. (5) At all the temperatures which have up till now been experimentally attained, no gas emits a line spectrum solely due to the temperature. This spectrum only occurs under the action of particular phenomena (chemical, electrical). (6) Gases can emit continuous and band spectra by simple rise of temperature. Whether or not line spectra also might be obtained by a sufficiently high temperature cannot yet be affirmed. (7) In all sources of radiation in which chemical or electrical phenomena are present it seems that the law of Kirchhoff does not apply.

As these phenomena are very probably present in the luminous stars, one ought not to apply the law to problems in physical astronomy.

The report concludes with some theoretical considerations as to what particles (atoms, molecules, or electrons) in a gas the spectral radiation is due.

J. B. H.

1071. *An Optical Illusion.* **J. Drecker.** (Phys. Zeitschr. 2. pp. 144–145, 1900.)—Wind's supposed discovery of the diffraction of Röntgen rays has since been explained as an optical illusion [see Abstract No. 1647 (1900)]. The illusion can be produced by letting a rectangle be illuminated across a breadth AA′ with uniform brightness, and flanking each side with patches AB, A′B′ of uniformly diminishing brightness (see diagram, where the ordinates represent brightnesses).



A dark fringe then appears in the centre of AA′. On cutting off AB, A′B′, the portion AA′ again appears uniformly illuminated.

E. E. F.

1072. *De-ionisation of Air.* **E. Villari.** (Phys. Zeitschr. 2. pp. 360–361, March 16, 1901.)—Villari found [Abstract No. 1803 (1900)] that air, previously ionised by Röntgen rays, was de-ionised by passing it over a metallic surface, and that the latter thereby became charged. Dorn [see Abstract No. 800 (1901)] suggested an explanation based on the differences which, according to Zeleny, exist between the velocities of the positive and negative ions. If Zeleny's results are correct, moist ionised carbon dioxide should impart a charge of opposite sign to that imparted by other gases.

Villari finds that this is not so. For example, moist ionised carbon dioxide passing over iron gave the latter a negative charge, and so also did moist ionised air—the only difference being that the electrometer deflection was twice as great for air as for carbon dioxide.

D. E. J.

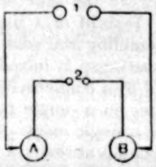
1073. *Duration of Emission of Röntgen Rays.* **B. Brunhes.** (Soc. Franç. Phys., Bull. 163. pp. 1–3; Discussion, pp. 3–4, 1901.)—The author refers to his experiments already published [see Abstracts Nos. 828 and 1801 (1900)] and describes further experiments. He finds that the emission of Röntgen rays lasts for a finite time, the duration being of the order of $\frac{1}{10000}$ to $\frac{1}{12000}$ of a second. In one experiment he connects a spark-gap and the Crookes tube in series with the secondary of an induction coil, and finds that while the spark always gives on a screen as clear and distinct images of a hole in a disc revolving rapidly as when the disc is at rest, thus showing it to be instantaneous, the Crookes tube, on the other hand, gives throughout a single image on the fluorescent screen. He accounts for the phenomenon by saying that the exact instant at which the spark passes is that at which the gaseous molecules strike the kathode in the Crookes tube. It is only afterwards that these molecules are repelled by the kathode, and this flux of kathode rays, spreading out and creeping to the anti-kathode, strikes it during a finite time.

In the discussion **P. Villard** said the experiments described confirmed his own experiments on the duration of the emission of kathode rays, if we suppose the transformation of these rays into Röntgen rays to be instantaneous at the moment of striking. Thus the duration of emission of the Röntgen rays would be really that of the kathodic emission. **Colardeau** described experiments he had made, but not yet published, to show that the effects vary greatly according to the arrangement of the discharge circuit of the coil. If the Crookes tube is connected up directly to the terminals of the secondary it is traversed by several consecutive discharges even with a single interruption of the primary circuit. This was shown by directing the Röntgen rays on to a photographic plate revolving rapidly round an axis perpendicular to its plane, and interposing between the tube and the plate a piece of metal with a straight slot cut in it. Instead of a single image, a series of images was obtained, somewhat resembling the solar spectrum spread round the sector of a circle. But if a spark-gap is introduced into the circuit and the poles of the secondary shunted by a condenser of sufficient capacity to make the whole discharge take place in a single passage through the tube, the photographic plate shows only a single image of the slot, and this image is as clear as that given when the plate is at rest. A duration of about $\frac{1}{50000}$ of a second would have given a very noticeable enlargement of this image, and the speaker therefore concluded that the true duration of emission of Röntgen rays by a single discharge would be under this limit. In his reply to the discussion **B. Brunhes** maintained that in the conditions under which he had worked there was a clear difference of speed between the emission of the Röntgen rays and the spark in series with the Crookes tube, the former lasting $\frac{1}{10000}$ of a second while the spark was instantaneous. His photo left no doubt on this point. W. C. H.

1074. *Transparency to Röntgen Rays.* **L. Benoist.** (Comptes Rendus, 132. pp. 324–327, Feb. 11, 1901.)—Having shown that the absorbing power or specific opacity of a body increases with the density and that all bodies exercise a selective absorption on Röntgen radiation, the author extends his researches to 120 bodies tested under the most varied conditions. Taking for his standard the absorption exercised by a block of paraffin 75 mm. thick and calling the equivalent transparency of a body the mass, in decigrammes, of a prism 1 square cm. base which produces the same absorption as his standard, it is found :—(1) The specific opacity of a body is independent of its physical state, *e.g.*, it is the same for water as for ice. (2) The opacity is independent of the mode of atomic grouping, *e.g.*, of crystalline form, allotropic state, &c. (3) It is independent of the state of liberty or combination of the atoms; thus the equivalent transparency of a combination can, with certain limitations, be calculated from the transparencies of its constituent elements. It is found, plotting atomic weights as abscissæ and the equivalent transparencies as ordinates, that these points lie on a regular hyperbolic curve. If, however, the character of the radiation is altered, either by altering the tube or interposing an absorbent screen, the same hyperbola is not obtained; from a study of these curves the fourth result is obtained, viz., (4) The specific opacity of simple bodies, measured under well-defined conditions, is a definite function of their atomic weight and increases with the latter, the proportionality being nearly direct for rays of the most penetrating kind. R. S. W.

1075. *Radio-activity of Matter.* **H. Becquerel.** (Nature, 63. pp. 396–398, Feb. 21, 1901.)—A historical summary. It appears that even the radio-activity of uranium is due to traces of some radio-active substance. A. D.

1076. *Transparency to Radium Rays.* **T. Mizuno.** (Electrician, 46. p. 399, Jan. 4, 1901.)—The differences in the transmission of radium rays through various substances may be readily shown by a spark method (see diagram). To each of the poles A and B of an induction coil were respectively attached two wires forming the alternative spark-gaps 1 and 2, as shown in the annexed figure. These spark-gaps were formed by spark micrometers, so that the spark-lengths could be finely adjusted at will. Now suppose that one of the spark-gaps, say 1, is drawn apart just beyond its critical spark-length, that is to say, such a length across which the spark is just unable to spring, whilst the other spark-gap 2 is disposed just below its critical length. In this sensitive state of the spark-gaps, if we bring the radium preparation into the neighbourhood of the gap 1 vivid sparks will take place there, while the sparks in the gap 2 will be either very much enfeebled or completely annihilated. On bringing layers of various substances between the gap 1 and the radium preparation, the sparks passed the gap as long as the layers did not exceed a certain thickness, varying from one substance to another. E. E. F.



1077. *Secondary Radio-activity of Metals.* **H. Becquerel.** (Comptes Rendus, 132. pp. 371–373, Feb. 18, 1901.)—A block of lead 34 mm. long, 21 mm. wide, and 7 mm. high, has a groove cut in it 1·6 mm. deep, and in this is placed a layer 1 mm. thick of a salt of radium possessing strong radioactivity. After being eleven months in this position, salt and block are placed on a photographic plate wrapped in black paper and after an exposure of forty-eight hours the plate is developed. An intense impression is obtained, not only beneath the block, but at some distance from the lateral walls, in which case the radiation has traversed a thickness of lead varying from 12 mm. to 20 mm. This radiation is very penetrating, affecting each of three photographic plates placed one on the other. These effects are not due to vapour emitted by the metal, for a sheet of mica interposed between the block and the plate does not hinder their production. If particles of metal are placed on the plate at varying distances from the block, then, after the same exposure, it is found that each particle has affected the plate more strongly than the direct radiation has done. On the side exposed to the source there is an intense secondary emission; on the side more remote only the effect of the direct radiation appears, and another particle in the shadow of the former shows no secondary effects. The secondary radiation is easily absorbed, and the metallic fragments lose their activity when cut off from the exciting source. R. S. W.

1078. *Luminescence of Organic Compounds.* **R. Dubois.** (Comptes Rendus, 132. pp. 431–432, Feb. 18, 1901.)—The author finds that a number of essences, including otto of roses, become luminous when acted upon by cold alcoholic potash. The most marked result, however, was obtained with the glucoside æsculin, the luminescence of the alcoholic potash solution being in this case instantly destroyed by the addition of water. T. H. P.

REFERENCES.

1079. *Stroboscopic Phenomena.* **C. Barus.** (Science, 13. pp. 128–129, Jan. 25, 1901.)—Note on an appearance seen when the shadows of the revolving bars of a squirrel-cage are thrown on a near screen parallel to the bars. A. E.

1080. *Crookes Tubes for Radiography.* (Archives d'Él. Médicale, 9. pp. 36–37, Jan., 1901.)—A form of tube is described in which the anti-kathode is kept from unduly heating by being backed by a substantial copper rod. A. D.

1081. *Infra-red Spectrum.* **H. Rubens.** (International Physical Congress at Paris, Report, 2. pp. 141–174, 1900.)—This paper furnishes a detailed historical summary of the investigations which have been made concerning the infra-red spectrum, commencing with Herschel's observation of 1800; the author describes the various instruments which have been employed in the determination, the dispersion formulæ for the reduction of observations, and the method of graphically plotting out the spectrum from the bolometric records. C. P. B.

1082. *Distribution of Spectrum Lines.* **J. R. Rydberg.** (International Physical Congress at Paris, Report, 2. pp. 200–224, 1900.)—A *résumé* of the work which has been done in the way of classifying the spectra of the elements, and arranging their lines in series. Tables and curves are given illustrating conclusions deduced from the results. The report includes a classified index to the literature of the subject. Line spectra are provisionally classed under the headings type I., and type II.; type I. comprising those spectra which can be resolved into sets of infinite series of lines converging to finite limits; type II. those which cannot, though in this case the lines can be arranged in rows and columns which exhibit constant differences of wave-number. The results of research into the constitution of spectra of type I. are summed up in some comparatively simple laws. Banded spectra, and line spectra of type II. have not yet been sufficiently investigated to permit of a comparison between the different elements. A. E.

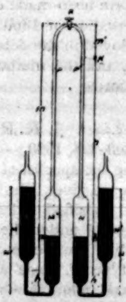
1083. *Theoretical Laws of Radiation.* **W. Wien.** (International Physical Congress at Paris, Report, 2. pp. 23–40, 1900.)—The points treated in this report are as follows: Kirchhoff's law, Temperature of radiation, Wien's paradox [see Abstract No. 71 (1901)] Boltzmann's thermodynamic proof of Stefan's law, also another proof of the same, the thermodynamic proof of Wien's formula for the partition of energy in the spectrum of a black body, and a discussion of Planck's deduction of the same formula from the electromagnetic equations representing the oscillations of an electric dipole. J. B. H.

HEAT.

1084. *Thermal Conductivity of Air.* **E. Müller.** (Phys. Zeitschr. 2. pp. 161–165, 1900.)—The author shows that the coefficient of thermal conductivity of air increases more slowly with the temperature than does the coefficient of viscosity. Kundt and Warburg's thermometer-bulb method is not suitable for absolute measurements. E. E. F.

1085. *Specific Heat of a Gaseous Mixture of Bodies in Chemical Equilibrium.* **A. Ponsot.** (Comptes Rendus, 132. pp. 759–761, March 25, 1901.)—If there are two systems in chemical equilibrium, that which by its formation increases the volume of the mixture and which displaces the other when the volume increases is also that into which the gaseous mixture tends entirely to pass when the temperature increases without limit, whether at constant pressure or at constant volume. Its formation increases the specific heat of the mixture, and this increase is larger for constant pressure than for constant volume. R. E. B.

1086. *Boyle's Law at Very Low Pressures.* **A. Battelli.** (N. Cimento, 1. pp. 5–40, Jan., and pp. 81–111, Feb., 1901. Phys. Zeitschr. 2. pp. 409–411, April 6, 1901.)—The author's method eliminates various sources of error attaching to previous investigations, or determines their amount. The apparatus consists essentially of two cylinders of glass or iron, communicating with each other and with a special micromanometer. A compression pump, communicating with one of the cylinders from below, brings the mercury to the level of two marks, one at the lower end and one at the upper end of the cylinder. All the parts may be connected with a set of desiccating tubes furnished with hygroscopic wadding. When the mercury stands at the lower mark, the air pump is worked until the pressure desired is obtained. When the pressure has been read off, the mercury is made to rise to the upper mark. When the charge of volume is known, and the charge of pressure and the temperature of the apparatus are determined, all the necessary figures are given. The substitution of iron for glass was made in order to determine the disturbing influence of absorption by the cylinder walls.



The author used a delicate micromanometer of the form shown in the diagram. M, M′, N, N′ are four cylindrical vessels of the same shape and volume. R is a three-way cock used for filling. M and N′ are connected with the compression apparatus by perfectly fitting cocks and contain mercury which rises to *a* and *b* in M′ and N. M′ contains water, which reaches as far as K. The rest of the tube and N contain aniline, the two liquids having a very slight difference of density. The displacement of the meniscus indicates differences of pressure as low as 0·001 mm. of mercury. The results show that air has a deviation from Boyle's law between 2 and 5 mm., and another at about 0·1 mm., the latter being, however, somewhat uncertain. Hydrogen obeys the law down to 0·02 mm. Oxygen shows a break at 0·7 mm. Carbon dioxide shows greater compression than it should show at very low pressures, but that may be due to an undiscovered absorption by the walls of the vessel.

E. E. F.

1087. *Thermodynamical Properties of Superheated Steam and the Dryness of Saturated Steam.* **J. H. Grindley.** (Manchester Lit. and Phil. Soc., Mem. 45. 3. pp. 1–11, 1900–1901.)—For superheated steam, (1) the author draws up from his former experimental results [Abstract No. 1436 (1900)] a table of the total heat of its formation at different pressures and temperatures from water at 32° F.; (2) by utilising Ramsay and Young's experiments he calculates the values of the isopiestic specific heat for temperatures between 290·3° and 426·5° F.; these, compared with the values formerly found by employing Regnault's linear relation between the total heat of saturated steam and the temperature, throw doubt on this relation; (3) he finds that for adiabatic change between 1 and 5 atmospheres and 210° and 330° F. the values of pv^n are constant when $n = 1{\cdot}286$; (4) he shows that the product of the isopiestic specific heat and the cooling effect on expansion is D/a^p for pressure p, where $D = 1{\cdot}625$ and $a = 1{\cdot}000023$ when p is measured in lbs. per square foot.

For dry saturated steam the specific volumes deduced from Ramsay and Young's experiments and those lately given by Callendar agree in differing from those obtained from Regnault's values for the latent heat by amounts varying from 1·33 per cent. under 1 atmosphere to 3·4 per cent. under 21 atmospheres in excess, thus apparently showing that Regnault's values for the latent heat are too small by these percentages. R. E. B.

1088. *Characteristic Equation of Fluids.* **D. Berthelot.** (Archives Néerlandaises, 5. pp. 417–446, 1900.)—An excellent *résumé* of the modifications of van der Waals' equation which have been suggested and of the results deducible from them, with special stress on the principle of corresponding states. [See also Abstract No. 842 (1900).] R. E. B.

1089. *The $t\phi$-diagram.* **L. Marchis.** (Comptes Rendus, 132. pp. 671–673, March 18, 1901.)—The heat absorbed in any process is $\int t\,d\phi$ only when the process is reversible, or the system free from viscosity or friction. Thus areas on the $t\phi$-diagram cannot represent the heat absorbed or given out by a steam engine, as of late has very often been assumed; for, even if during expansion and compression the steam may be taken to be of the same temperature throughout, it certainly is not so during admission and exhaustion. Still less can a $t\phi$-diagram be employed in the case of a gas-engine, in which irreversible explosions also occur. R. E. B.

SOUND.

1090. *Speaking Flames.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 325–328, Feb. 23, 1901.)—Flames other than the electric arc will produce sound, relatively weak, under the influence of periodic variations of electric current. With a Bunsen burner connect the microphone circuit with the low voltage coil of a transformer; lead the current in the secondary coil to the Bunsen burner, through the flame, and back through a strip of platinum foil in the flame. In order to preserve timbre, the lamp-current I_2 should be independent of *n* the frequency. In order that I_2 may be a maximum, so as to promote loudness, it must be proportional to the variations of resistance in the microphone, to the microphone current, to the coefficient of mutual induction, and to the frequency *n*, and inversely proportional to the resistances in the primary and secondary circuits. Higher tones are therefore better transmitted than lower. For maximum loudness the self-induction coefficients must be in the ratio of the square roots of the number of windings; and the number of windings of the two coils must be in the ratio of the square roots of their resistances or, practically, in the ratio of the square roots of the microphone circuit and lamp-circuit resistances. This explains why if we increase the lamp-current by diminishing the resistance, the loudness falls off. The author uses with success in reproducing speech loudly with an arc-lamp a transformer with 2½ times as many windings in the secondary as in the primary; the lamp working at 110 volts and about 10 amperes. With the Bunsen burner, since the resistances are greater, the secondary coil must have a correspondingly greater number of windings. It is of advantage, therefore, to have a transformer in which the ratio of turns is adjustable. This may be effectively done by passing the main current through a coil with core and passing the microphone current through an adjustable smaller number of turns of the same coil; in which construction the resistance of the coil may be so determined that there is no need of a separate microphone battery. An arrangement of several microphones is described, each with its own transforming coil, to enhance the microphone current; applicable also to loud-sounding telephone work. Remarks are made on the use of selenium cells for phototelephony, and even for working the high-resistance writing needle of a telegraphone. A. D.

1091. *Manometric Flame applied to Telephone.* **L. W. Austin.** (Phys. Rev. 12. pp. 121–124, Feb., 1901.)—Method described of photographing a manometric flame actuated by the movements of the diaphragm of a telephone receiver. The lower line of the luminous part of the flame follows quite accurately the motions of the diaphragm. The rise in the top of the flame is, with oxy-coal-gas, sensibly proportional to the voltage across the terminals of the telephone; with acetylene it is somewhat more rapid than that of the voltage. A. D.

1092. *Improved Photophone.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 339–340, March 2, 1901.)—The transmitter consists of the usual telephone disc, to which is attached a lime cylinder on which a blowpipe flame plays.

The author finds this arrangement very sensitive, and also recommends the use of a carbon dust microphone instead of a selenium cell as receiver.

J. E.-M.

1093. *Measuring the Vibration of a Transmitter Diaphragm.* **W. L. Merrill.** (Amer. Electn. 13. p. 67, Feb., 1901.)—The vibration of a telephone transmitter is measured by means of a ray of light reflected from a small mirror cemented to a steel pinion set in watch jewels. To the centre of the diaphragm is soldered a needle which presses on a steel arm. This arm is perpendicular to the pinion and in the plane of the mirror. The slightest vibration is transmitted through the needle and arm to the mirror, causing it to oscillate and thus deflect the beam of light. In an experiment a diaphragm excursion of one three-thousandth of an inch deflected the spot of light on a screen 25 feet away 2 inches. The ticking of a watch gave noticeable deflections, and loud sounds produced deflections of 2 feet. A. R.

1094. *Propagation of Sound between Parallel Walls.* **Rayleigh.** (Phil. Mag. 1. pp. 301–311, March, 1901.)—Kirchhoff treated the influence of viscosity and conduction of heat on the propagation of sound in a gas contained in cylindrical tubes of moderate radius, and his investigation is given in Rayleigh's Treatise on Sound (2nd edition, § 348). In the present paper Rayleigh begins with a recapitulation of Kirchhoff's theory. The condition of the gas at any point x, y, z is defined by the velocity components u, v, w, and θ' the excess of temperature : θ' is given by the equation—

$$\theta' = A_1Q_1 + A_2Q_2,$$

in which A_1, A_2 are arbitrary constants and Q_1, Q_2 are functions of x, y, z, satisfying the equations—

$$\nabla^2 Q_1 = \lambda_1 Q_1, \qquad \nabla^2 Q_2 = \lambda_2 Q_2,$$

λ_1, λ_2 being the roots of a certain quadratic equation.

Rayleigh passes on to the case in which two planes parallel to that of xz, namely $y = \pm y$, are substituted for Kirchhoff's cylinder. The solution obtained differs from Kirchhoff's only by the substitution of $2y_1$, the distance between the planes, for r the radius of the cylinder. So far as it depends on x, the solution is of the form $u = \varepsilon^{int}\varepsilon^{-m'x-im''x}$, m' and m'' being constants depending on the coefficients of viscosity and conduction of heat.

So far as regards y, it is found that, except in the immediate neighbourhood of the walls, $u = -\frac{Q_1(y)}{Q_1(y_1)}$, and is approximately constant. Rayleigh then considers the value of u when y_1 is very great, and finds that *the phase* varies with y, so that constancy of phase requires that as y increases x should diminish, or the wave surface is convex towards positive x and the wave divergent.

The solution, as is pointed out by the writer, fails to answer the practical question that he himself had proposed, namely, whether in the passage of sound over smooth water there is any appreciable *shadow* formed near the surface under the influence of viscosity and heat conduction. The result is that this effect may be neglected in practice except for an observer very near the water. S. H. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1095. *Electric Inertia.* **A. Schuster.** (Phil. Mag. 1. pp. 227–238, Feb., 1901. Paper read before the Physical Society of London.)—In the immediate neighbourhood of an ion the magnetic field will be many times greater than that calculated on the supposition of continuous distribution, and hence the total magnetic energy is under-estimated. The author, proceeding on the basis of the electron theory, calculates the additional terms which become necessary for the evaluation of self-induction. He finds the excess of magnetic energy per unit length of a row of electrically charged particles to be—

$$C^2\left(\frac{1}{3an} - 0{\cdot}842\right),$$

where C is the current, a the radius of the particles, and n their number per unit length. If N is the number of electrons in unit volume, i the current density, and μ stands for $2/3a$N, then the correcting term per unit volume of a conductor is—

$$\frac{1}{2}\mu i^2.$$

The flow of electricity will behave as if it had inertia, the apparent mass for unit current density and unit of volume being μ. The dimensions of μ, as pointed out by Hertz, are the same as those of a surface. The author uses the expression "electric inertia" for the quantity μ; the energy due to electric inertia is the energy of the magnetic field due to the moving electrons over and above that which is calculated in the usual way. The correction to self-induction for a conductor of length l and uniform cross-section A will be—

$$l/6\mathrm{NA}a,$$

if both kinds of electrons take equal parts in conveying the current. The correcting term increases in importance with diminishing cross-section, and might be made large if the cross-section could be reduced so as to be comparable with molecular dimensions.

As regards the chances of verifying the existence of this inertia experimentally, the author calculates that the effect would be much smaller than the extreme limits of Hertz's experiments on electric inertia. In metals, therefore, no results need be looked for, but if in a bad conductor, like carbon, the distance between the moving electrons should be, say, 50 times as great as that between the molecules, we should get within the limits to which Hertz worked. In the case of liquids and gases, the chances of experimental verification of inertia are equally remote, but a clear proof of such inertia may be looked for in the domain of luminous vibrations. E. E. F.

1096. *On Certain Fundamental Propositions in Electrical Theory.* **W. H. Julius.** (Archives Néerlandaises, 5. pp. 497–505, 1900.)—The electrostatical theory due to Gauss, Laplace, and Poisson rests on the conception of action at a distance between the particles independent of the intervening medium.

This theory has to be modified with regard to Faraday's discovery that the force has different values for different media. Without an extended investigation of these phenomena, the author proposes to show in this paper that by introducing the medium at the starting-point of our theory, some difficulties which arise in the usual treatment are made to disappear.

The theory is well known by which the action of the medium as shown by experiment can be explained on the hypothesis of little conducting particles being scattered through the space in question. Increasing these until they fill the whole space, the author converts it into a conducting body, and finds that ultimately within the body $0 = \frac{4\pi}{k}\rho$, where ρ is the volume density of electricity and k the specific inductive capacity. The usual interpretation is that within a conductor $\rho = 0$. The equation would be equally satisfied by making k infinite within a conductor.

The author then considers Gauss's theorem of the "integral normal." He puts this case: A sphere has a charge σ per unit of area of its surface. The normal force ought, according to Gauss's theory, to be $4\pi\sigma$, but is in fact only $2\pi\sigma$ according to Laplace's calculation. This difficulty is due, he says, to the hypothesis which we make as fundamental, that electrically charged points can be tested in the same way as mass under the law of gravitation. We should, he says, regard the surface charge on the sphere as consisting of two equal layers, of which only one side affects the field on the outside of the sphere. If the charged sphere had a concentric conducting spherical shell surrounding it and connected to earth, every element of that shell subtending a solid angle ds at centre would have an induced charge $-\sigma$, corresponding to σ on the corresponding element of the inner sphere. It is a property of the theory advocated by the author that the force which urges outwards the charge $+\sigma$ on the inner sphere might be ascribed to the attraction exerted by the charge $-\sigma$ on the outer shell, whereas in the ordinary theory the spherical shell, having uniform density $-\sigma$, would have constant potential at all internal points, and so emit no attractive force on the internal charged sphere. S. H. B.

DISCHARGE AND OSCILLATIONS.

1097. *Conditions for Electric Discharges.* **K. R. Johnson.** (Écl. Électr. 26. pp. 393–408, March 16, 1901.)—The initiation of an electric discharge is usually admitted to depend upon (1) the difference of potential of the electrodes; (2) the form and dimensions of the electrodes; (3) their distance apart; and finally (4) the nature, pressure, and temperature of the gas in which the discharge must pass.

To these Jaumann has added a fifth condition, viz., *the variation of the magnetic field.* This has been contradicted by some physicists; the present paper mathematically discusses recent experiments and supports Jaumann's view of the matter. E. H. B.

1098. *Sparking Distance.* **W. J. Humphreys.** (Phys. Rev. 11. pp. 79–83, 1900.)—The outer coatings of two Leyden jars are connected together, and the inner coatings are connected respectively to the poles of a Wimshurst machine. The inner coatings are therefore oppositely charged. If the distance between the discharging balls is diminished to nearly the disruptive spark length, a glass rod brought up to the positive ball at the part of it facing the negative will generally cause disruption and allow a noisy spark to pass. But nothing of the kind happens when the rod is placed next to the negative pole, or, in fact, in any part of the field other than that very near the anode. Various kinds of dielectric have yielded the same results; the phenomenon can be shown by a silk thread stretched taut and approximately at right angles to the field. R. A.

1099. *Currents in Lightning Conductors.* **F. Pockels.** (Phys. Zeitschr. 2. pp. 306–307, Feb. 16, 1901.)—The author has previously shown that the residual magnetism of basalt depends only on the maximum magnetising field to which it has been exposed. This fact is here utilised to gauge the current in a lightning conductor. The experimental method consists in placing a basalt bar crosswise near the lightning conductor and testing it after a lightning discharge has passed. The expression connecting current and the other quantities concerned is given thus :—

$$i = \frac{5l}{2\tan^{-1}\left(\frac{l}{2a}\right)} \mathrm{H};$$

where i is the current in amperes, l the length of the basalt bar, a the distance of its middle point from the axis of the lightning conductor, and H the magnetising field which would produce the same effect on the basalt bar as the current in question. On examination of two bars exposed thus at the observation tower on Monte Cimone in the Appenines, it was inferred that the currents were respectively 10,200 amperes and 5,530 amperes. It is held that the maximum lightning current would be double these figures, or even more since the basalt bars were not tested till several months after the lightning discharge and had in the meantime suffered vibration which would partially demagnetise them. [See further Abstracts, Nos. 295 and 1256 (1898).]
E. H. B.

1100. *Magnetic Effect of Electric Convection.* **V. Crémieu.** (Comptes Rendus, 132. pp. 327–330, Feb. 11, 1901.)—The author has repeated his former experiments [see Abstract No. 144 (1901)] in which a negative result was obtained, in order to meet objections arising out of the effect of the metallic screens between which his revolving disc moved. An ebonite disc, covered with gold-leaf along three sectors, moves, in its lower half, between two glass plates covered on their outer faces with tin-foil which is earthed, in its upper half between two ebonite discs, also covered externally with tin-foil. By means of a spring, the revolving disc is charged when passing between the lower plates, while, as it passes between the upper ones, the effect on an astatic needle is noted. To protect the latter from air currents, a dielectric screen is interposed, but it is then found impossible to suppress electrostatic effects. Finally an astatic needle fastened to a mica sheet is used, the whole being screened by some conductor. Again it is found that the turning disc produces no magnetic effect. In some cases a deviation is obtained; but as this is of the same order when the needle is removed from its mica support, it is due to an electrostatic effect on the latter. With an aluminium support the same result appears, but in this case it is reversible with the charge and the direction of rotation. In no case was a deviation of the needle noted when it was electrically well screened. After noting the numerous difficulties attending such experiments, the author again states his opinion that under the conditions of the experiments of Rowland, Himstedt, or those he has recently performed, electric convection produces no magnetic effect. R. S. W.

1101. *Action of Magnetic Field on the Discharge through a Gas.* **R. S. Willows.** (Phil. Mag. 1. pp. 250–260, Feb., 1901.)—While working with tubes in which the pressure varied from 0·1 mm. to 1 mm. it was noticed that under certain conditions the imposition of a transverse field caused a large increase in the current passing and a decrease in the potential-difference of the terminals, just the opposite of what generally occurs. As this did not appear to be due to any peculiarity of the tube, further experiments were made. The results of these are given in the present paper.

The effect is found to vary with the magnitude and position of the magnetic field, with the pressure of the gas, and with the relative sizes of the electrodes. Experiments were made with the tube in a variable field, and also in a uniform field, and the potential gradient was measured between the electrodes with the field on and off. Curves are given showing the variation of current due to the field as a function of the pressure, when the field is produced at the anode, at the kathode, and between the anode and kathode. These curves are duplicated for the cases when the disc electrode is kathode and when it is anode. Curves are also given showing the difference of potential between the terminals, and also the potential gradient throughout the tube both when in and out of the magnetic field. J. B. H.

1102. *Distribution of Current at the Kathode of a Vacuum Tube.* **A. Wehnelt.** (Phys. Zeitschr. 2. pp. 334–339, March 2, 1901.)—An investigation of the circumstances affecting the distribution of current across the surface of the kathode. A kathode completely filling the section of the tube is used, the inner part, a circular disc, being separated from the outer, a concentric ring: the current through either part or through both together is capable of measurement by a galvanometer. The sum of the separate currents is constant over the range of pressure used, and when the whole electrode is covered with the glow the currents through the separate parts are in the ratio of their areas. As the pressure is lowered the glow is confined more and more to the inner disc, and the current through the ring decreases, showing that the current flows through that part of the tube only which contains visible rays. If the discharge is oscillatory the current through the inner portion of the kathode may exceed the whole current. This arises from the fact that the ring acts as anode to the inner part of the whole electrode. With hollow electrodes similar results are obtained; at low pressures it is only the external part of the kathode which is useful in carrying the discharge. If the kathode is a circular disc cut in half along a diameter and the halves are made of different metals, then at the higher pressures most of the current goes from that metal which possesses the least kathode fall of potential, but as the gas is pumped out the currents through the two parts become equal, so that when the dark space is a few mm. long the relative magnitude of the fall for the two metals has no influence. By means of a magnetic field the current, as measured by the galvanometer, is shifted in the same direction as the visible glow. The cleanness of the surface of the kathode is found to exercise a considerable influence at higher pressures on the current distribution. If the surface of the electrode is increased by cutting grooves in it, the amount of current from it is found increased in the same ratio as the surface when the pressure is such that the whole area is covered with glow; at lower pressures this again has no effect. R. S. W.

1103. *Conductivity Produced by Ions.* **J. S. Townsend.** (Phil. Mag. 1. pp. 198–227, Feb., 1901.)—In a previous paper [see Abstract No. 2449 (1900)] the author described some researches which led him to the conclusion that negatively charged ions, moving through a gas, produce other ions, although the force acting on them is very small compared with the force necessary to produce the ordinary vacuum tube or spark discharges. He now gives a more complete account of these experiments, and shows that at low pressures the current may be considered to pass through three stages as the e.m.f. is increased. In the first stage, the current increases with the e.m.f.; in the second stage, the current remains practically constant and shows only small variations for comparatively large changes in the force; in the third stage, the current rapidly increases with the e.m.f. It is the negative ions which produce the large increases of conductivity. The velocity acquired by a negative ion in travelling freely between two points differing in potential by 4 volts is 10 times as great as its velocity of agitation at ordinary temperatures. The number of collisions made by an ion in going through a centimetre of air at 1 mm. pressure is 21. At atmospheric pressure, each ion would produce some 10,000 other ions per centimetre, and the same number would be produced by a particle conveying "Becquerel rays." E. E. F.

1104. *Electric Waves of a Vibrating Ion.* **A. Righi.** (Archives Néerlandaises, 5. pp. 348–355, 1900.)—This paper begins with a general solution of the equations for an electric doublet, including, as a particular case, the solution originally given by Hertz. The mathematics is then developed for the case of a very small vibration at the source of the radiation, and is found to be in agreement with the result of putting the distance from the source great in Hertz's solution for his oscillator, viz., transverse waves, with the electric and magnetic vectors at right angles to each other in the wave front.

The view is then put forward that the vibrations of the particles in a luminous source may be regarded as the electric oscillations of a very small Hertzian oscillator. It is then shown that the charge on the ion may be supposed either positive or negative, and the bearing of this view on the Zeeman effect is discussed, especially the case where the ion executes a small circular motion. E. H. B.

1105. *Refraction of Electric Waves.* **G. Pierce.** (Phil. Mag. 1. pp. 179–198, Feb., 1901.)—By means of a modification of Boys' radio-micrometer [see Abstract No. 1848 (1900)], the author has measured the refractive indices of paraffin, ebonite, and various specimens of wood. The movable coil of the apparatus is traversed by thermoelectric currents produced by electric waves impinging upon a knot of fine platinum and platinum-nickel wire and heating up the junction. The measurements of refractive indices were made by observing the distance by which the interposition of a known thickness of the dielectric displaces the nodes of a stationary wave in air. The arrangement of apparatus for obtaining the stationary wave is essentially that of Lloyd's mirror for perpendicular incidence, the succession being radio-micrometer, oscillation, dielectric, and metallic mirror. The refractive indices of paraffin and ebonite for waves 4·4 cm. long were found to be 1·56 and 1·75 respectively. All the woods examined showed double refraction, black walnut, with indices 1·70 and 1·49 respectively, showing the largest divergence. The author shows from theoretical considerations that it is a case of true double refraction, and not an appearance due to differences of absorption. E. E. F.

1106. *Velocity of Propagation of Electric Waves.* **R. Blondlot** and **C. Gutton.** (International Physical Congress at Paris, Report, 2. pp. 268–

283, 1900.)—The Report contains brief accounts of the various methods of measurement which have given the following results (expressed in kilometres per second :—Blondlot (1891), 302,200 ; Blondlot (1893), 296,400 and 298,000 ; Trowbridge and Duane (1895), 300,300 ; C. A. Saunders (1897), 298,200 and 299,700 ; Maclean (1899), 299,110. D. E. J.

1107. *Hertzian Waves.* **A. Righi.** (International Physical Congress at Paris, Report, 2. pp. 301–324, 1900.)—This report deals with the practical applications of Hertzian waves and their identity with luminous waves. (1) *Apparatus for Producing and Studying Hertzian Waves.*—The intensity of the waves is increased by enclosing the spark-gap in an insulating medium (Sarasin and de la Rive). Righi finds that vaseline oil is the best liquid for this purpose. For experiments analogous to optical ones the waves have to be as short as possible. The most suitable oscillator consists of two spheres of copper separated by a layer of vaseline oil. In this way Righi obtained waves only 2·5 cm. long, and since then waves only a few millimetres in length have been obtained (Lebedef). A suitable resonator for use with this oscillator consists of a small piece of silvered glass, part of the metallic layer being removed so as to form a spark-gap a few thousandths of a millimetre broad. Some twenty other forms of indicator or resonator are described. (2) *Radio-conductors.*—Their mode of action is discussed, and also their application. (3) *Optics of Electric Waves.* — A *résumé* of experiments on interference, diffraction, absorption, transmission, reflexion, and refraction. (4) *Telegraphy by Hertzian Waves.*—A similar *résumé*, with a discussion of the action of the antennæ, maximum distance, secrecy, &c. D. E. J.

1108. *Wireless Telegraphy and Electrodynamics.* **M. Abraham.** (Phys. Zeitschr. 2. pp. 329–334, March 2, 1901.)—A mathematical paper dealing with electrical oscillations in a conductor similar to that used by Slaby in his experiments on the tuning of the transmitter and receiver. In previous papers the author has already investigated, on Maxwell's theory, the circumstances of the oscillations set up in a vertical wire for free and forced periods, and has shown the results agree with theory. In the present paper, assuming the free end of the wire to be a current node, the same results are approximated to by the use of much simpler analysis. A simple geometric construction is given, whereby the nodal points can be found. The energy lost by radiation during a complete period is found, as also that dissipated by heat. In the particular case of a wire 50 m. long and 0·5 mm. radius, it is found that the amplitude of the vibration sinks to $1/e$ of its initial value after 5 periods on account of losses by radiation, while 80 are required if losses due to dissipation of heat only are taken into account. With a receiver of the Slaby type, it is found theoretically that there is a much smaller logarithmic decrement, on account of the earth acting as a reflector for the horizontal wire. R. S. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1109. *Dielectric Constants of Pure Liquids.* **B. B. Turner.** (Zeitschr. Phys. Chem. 35. pp. 385–430, 1900.)—This paper describes measurements made by the author to determine with the greatest possible accuracy the dielectric constants of certain pure liquids of a well-defined character, so that these liquids may serve as standards in other investigations. The method employed is Nernst's, in which the liquid is contained in a metal vessel, forming one plate of the condenser, while a plate fixed to a stem passing through an insulating cover forms the other plate. Three different processes are applicable: (1) Comparison of the constants of two liquids by measurement of the capacity of the empty vessel, and of its capacity when filled with each liquid; (2) Absolute determination of the constant by measurement of the capacity of the vessel both when empty and filled, with the internal plate at different distances from the bottom; (3) Determination of the constant by measurement on the full and empty vessel, first with the plate attached to its stem, and then with the stem alone. The author discusses the distribution of the lines of force between the plate and stem and the vessel; the variations in this distribution, when the dielectric, or the height of the plate, is varied, introduce error into the methods mentioned. The error is reduced to a minimum in the third method, and it is this which the author employs in his measurements. He describes numerous improvements and modifications introduced into the measuring vessel, the adjustable condensers and resistances, as used by Nernst (Zeitschr. Phys. Chem. **14.** p. 622, 1894), and gives details of a long series of tests carried out on the apparatus itself; from these he concludes that the method is capable of giving a value of the dielectric constant to within 1½ to 2½ per thousand. The following are the results obtained on various liquids:—

Benzol.—Pure benzol was twice purified by freezing out half its volume, and then was dried by sodium and distilled. Boiling-point, 80·33° — 80·36°. Dielectric constant, at 18° C., 2·288 ± 0·0008.

Ether.—Commercial ether was shaken up seventeen times with small amounts of water, then dried with calcium chloride, and distilled over sodium. Dielectric constant at 18° C., 4·367 ± 0·0018.

Aniline.—Aniline was purified in several different ways, the different samples showing some differences in their constants; the mean value was at 18° C., 7·298 + 0·014.

Ethyl chloride gave a value at 18° C. of 10·90 ± 0·01.

o-Nitrotoluol was purified by twice freezing out, and dried by fractional distillation. Its dielectric constant at 18° C. is 27·71 ± 0·05.

Water was purified by distillation with phosphoric acid, and then with baryta water in a stream of air free from carbonic acid; the conductivity was 1×10^{-6} absolute units. The constant was 81·07 ± 0·19.

Nitro-benzol, fractionally distilled, and twice frozen out, gave a constant of 36·45 ± 0·07.

Metaxylol, fractionally distilled over sodium, gave a constant at 18° C. of 2·376 ± 0·001.

The author then gives a table of dielectric constants of different substances, not, however, purified and measured with the same care as those mentioned. As standard liquids he recommends benzol, *o*-nitrotoluol, and water. G. H. B.

1110. *Dielectric Strength.* **J. R. Bibbins.** (Elect. World and Engineer, 36. pp. 279–282, 1900.)—The author has collected the results of various experimenters concerning the relation between thickness of dielectric and the corresponding disruptive potential. So far as it is possible to generalise, he concludes that for an uniform field in air the sparking distance, for small thicknesses, is a quadratic function of the potential; for greater thicknesses the sparking distance is a simple linear function. Also for solids and liquids the spark length in an uniform field, for comparatively small thicknesses, is taken to be a linear function of the potential. Steinmetz, in his experiments with air and liquids, separated the electrodes by pieces of glass or mica of measured thickness, these being perforated to allow the spark to pass through the material under test. Further experiment has proved that the introduction of the foreign substance into the field invalidates the results. If a metal disc is introduced between the electrodes, the disruptive potential may be much greater than without the disc. To explain this the author supposes a counter e.m.f. to exist at the various surfaces of separation of metal and air [see, however, O'Gorman's paper "Insulation on Cables," read Inst. of E.E., March 7, 1901]. The effect of increased frequency, when using alternating potentials, is to increase the convection currents indicated in air by a partial breaking down of the air stratum previously to the final disruption. Within the limits of frequencies 60–125, the effect of a change is not apparent; for high frequencies the convective discharges are very great, and the striking distance is largely increased. The corona, or luminous effect, observed when testing mica, should not be mistaken for disruptive discharge. The length of spark which then discharges over the surface is many times greater than can be accounted for by the corresponding calculated potential. R. A.

1111. *Temperature and the Dielectric Constant of Gases.* **K. Bädeker.** (Zeitschr. Phys. Chem. 36. pp. 305–335, Feb. 22, 1901.)—Let k be the dielectric constant, n_∞ the index of refraction for $\lambda = \infty$, $\kappa = k - 1$, $\nu = n - 1$; then from Maxwell's and Clausius and Mossotti's formulae, (1) that $k = n_\infty^2$ and (2) that $(k-1)/(k+2)$ is proportional to the density, we find $\kappa = 2\nu_\infty = \kappa_0 \frac{p}{76} \cdot \frac{1}{1+\alpha t}$. The work of Boltzmann (Pogg. Ann. 155, 407, 1875) of Klemenčič (Exner's Rep. 21, 571, 1885), of Lebedew (Wied. Ann. 44, 288, 1891), of Linde (Wied. Ann. 56, 546, 1893), all upon gases, is reviewed; as also that of Linde (same reference), Goodwin (Phys. Rev. 8, No. 40), Hasenoehrl (Communications Laborat. Camerlingh Onnes, No. 52, Leyden, 1899), and Dewar and Fleming (1899) on liquefied gases. Nernst's Wheatstone bridge method for gases (Zeitschr. Phys. Chem. 14, 622, 1894, and Philips in vol. 24 of the same, 1897), has been used in this research, with modifications described. The value $k = n_\infty^2$ is a minimum value of k. For normal gases $\kappa T = \kappa_0 T_0$. The research covered CS_2, SO_2, NH_3, HO_2, HCl, CH_4O, C_2H_6O, and $N_2O_4 \rightleftarrows 2NO_2$, in their relations to temperature. Where Maxwell's law fails to apply with changes of temperature, the Clausius-Mossotti formula is also invalid: and the two laws go hand in hand. Maxwell's law tends to be obeyed at high temperatures.
A. D.

1112. *Capacity of Dielectrics in a Magnetic Field.* **E. C. Roberts.** (Phys. Rev. 12. pp. 50–52, Jan., 1901.)—Sheets of glass, hard, rubber and vulcanite (composition not given) were coated with tin-foil 5·3 cm. square, and were placed in a field of 1,500 lines per square cm., but no variation of capacity noted when the field was put on or off. A similar test was made with alternating pressure with similar negative results. A third more accurate method was used, capable of indicating a change of $\frac{1}{3500}$ of the whole capacity. The results of the experiments were entirely negative. M. O'G.

1113. *Variation of Dielectric Constants.* **M. v. Hoór.** (Elektrotechn. Zeitschr. 22. pp. 170–172, Feb. 21; 187–191, Feb. 28; and 213–215, March 7, 1901. Abstract of a paper read before the Hungarian Academy of Science, June 18, 1900.)—This paper is a description of experiments undertaken to investigate the variation of the constant of a dielectric under different polarising forces. A condenser was constructed with dielectric consisting of two sheets of linen-paper, 0·045 mm. thick. The paper was dried at 110° C., then heated between copper sheets till just browned, and then soaked in petroleum ; the condenser when built up was soaked in petroleum in a vacuum of 80 mm. of mercury, for 150 hours ; during this process the hysteresis loss in the condenser fell to about one-fifth of its original value. Measurements were made with a ballistic galvanometer, and also with alternate currents ; full details are given in the paper of the methods employed and of the instruments used.

The maximum pressure between the terminals of the condenser was 954 volts, which, with the dielectric thickness of 0·009 cm., gave a value of the rate of fall of potential of 353 electrostatic c.g.s. units, a value very much higher than that reached by any other experimenter. At this pressure the polarisation energy per cubic cm. of dielectric was $0{\cdot}00128{\cdot}10^7$ erg, corresponding to the energy lost in cast-iron at an induction of about $B = 13000$. Tables and curves are given showing the results, and indicate considerable variation in the capacity with change in the pressure ; within the limits of the observations, the dielectric constant of the paper varied from 2·67 to 17·6.

In another series of experiments, curves of the rate of discharge of the condenser were taken by means of a damped mirror electrometer, the condenser being left to discharge through its own internal resistance. The resulting curves are shown between time and both $\log \frac{V_0}{V_t}$ and $\log \frac{Q_0}{Q_t}$, Q being the charge in the condenser.

These curves should be straight lines, were the dielectric properties constant ; they are, however, found to curve towards the axis of abscissæ, the charge curve bending over more than the pressure curve ; in other words, the pressure and the charge diminish with time more slowly than they would if the dielectric properties were constant. Comparison of the capacity curves as found by this method, and by the ballistic galvanometer, showed a very close agreement.

Finally the author describes experiments in which the pressure is varied by steps, and a hysteresis curve is given, which is exactly similar to the ordinary loop curve showing magnetic hysteresis. The loss of energy in hysteresis increases as the 1·7th power of the electrostatic induction.

G. H. B.

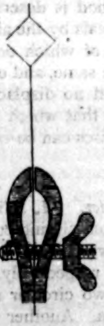
1114. *Function of Self-Induction in Wehnelt's Interrupter.* **T. Mizuno.** (Phil. Mag. 1. pp. 246–250, Feb., 1901.)—A series of experiments with a Wehnelt's interrupter in circuits of variable self-induction and capacity have led the author to conclude that in the action of an interrupter the function of self-induction is to break down the film of vapour formed at the electrode. The formation of this film stops the current, but, if the self-induction of the circuit is sufficiently great, the inductive current sparks through the vapour, breaking down the film and re-establishing the circuit.

J. B. H.

1115. *Decrease of Electrical Resistance by use of Low Temperatures.* **R. Mewes.** (Elektrochem. Zeitschr. 7. pp. 212–224, Jan., 1901.)—A theoretical discussion of the Dewar-Fleming researches, dealing mostly with the question of the boiling-point of gases at low pressures. The author begins with the fundamental formulæ of thermometry, and by means of these develops others (especially a new expansion formula), which give him values for the boiling-points of oxygen and nitrogen at given low pressures much larger than those found theoretically by Dewar from the formulas he used. The author points out wherein Dewar's formulæ are inaccurate, and shows that on applying his own formulæ to cases for which experimental data can be obtained, the calculated values approximate very closely to the observed values. The formula for the decrease of electrical resistance with decrease of temperature is not given, but is stated to be exactly similar to the author's expansion formula. W. C. H.

1116. *Frequency of Alternating Currents.* **R. Wachsmuth.** (Ann. d. Physik, 4. 2. pp. 323–326, Feb., 1901.)—This is a description of an exceedingly simple method of determining the frequency of an alternate current, being superior as regards simplicity even to that of Samojloff [see Abstract No. 117 (1901)].

It consists of a piece of watch-spring (see diagram) clamped in a vice, and provided with a small square piece of white paper stuck on by means of a bit of wax. When this is illuminated by a source fed by an alternating current and set vibrating, it will appear to stand still when the frequency of the current equals its own frequency of oscillation. The latter can be calculated from the formula, $N = 7920$ thickness in mm. / (length in cm.)^2, but in practice a graduation could be easily marked on the spring itself. A small correction must be added for the paper in the case of light springs. The method is very convenient, and can be used for frequencies up to 150 per second, beyond which the springs become too stiff. E. E. F.



1117. *Volta Effect.* **Q. Majorana.** (Archives des Sciences, 11. pp. 266–281, March, 1901) [Compare Abstract No. 632 (1901).]—The present theories are practically two—contact effect and Lodge's tendency to chemical action. The latter would imply that two different metals, perfectly polished and deprived of all adherent air, have no potential difference, which has not been proved. Experiments as to differing potential-differences in different gases are inconclusive, since the condition of the surface is altered by the film of adherent gas. A method is described for measuring the Volta effect: a filament of quartz, silvered and charged at, say, 250 volts, is suspended between spheres of the two metals; the two spheres are connected by a wire put to earth, in which is a loop with two branches; in the one branch is a 100-ohm resistance coil, in the other is a similar coil, R_2, and an accumulator of great capacity, and, say, 2 volts. In front of this loop the connecting wire is put to earth. Adjustment of the resistance coils enables the potential of the corresponding metallic sphere to be regulated from 0 to 2 volts by steps of 0·002 volt. The resistance coils are so used that $R_1 + R_2$ is always equal to 100 ohms : this is effected by taking out all the plugs from one box and always transferring to that box any plug taken from the other. With one box filled with its plugs adjust the position of the silvered quartz fibre until it always swings towards one of the metallic spheres or the other according to the sign of its electrification; then adjust the plugs until the quartz fibre acts in the same way or does not move at all, whatever be the sign of its electrification. The two spheres are then at equal potentials, and the original difference of potential between the two metal spheres is $e = VR_1/(R_1 + R_2) = VR_1 / 100$, where V is the voltage of the accumulator. The effects of different conditions of polish are traced out, also that of low temperatures (liquid air). If a metal is kept for a very long time in a very dry gas, it becomes more negative, apparently as the result of drying merely : the similar effect of slight heat upon Au, Ag, Fe, Cu, may be due to the same cause. A method is described for ascertaining the mutual attraction between different metals by the aid of interference fringes of light passed between the two discs, of which one is made mobile on a balance ; mathematical discussion of the same, and establishment of a null method in which there are no fringes, and no displacement of the discs, in which the compensating potential is twice that which is to be measured, and in which also the distance between the discs can be computed if the sensibility of the balance is known. A. D.

1118. *Carpentier's Potentiometer.* **M. Aliamet.** (Electricien, 21. pp. 1–5, Jan. 5, 1901.)—The potentiometer circuit consists of 11 coils of 1,000 ohms and 11 of 10 ohms in series ; two coils of each series are shunted by 10 coils of 200 ohms and 10 of 2 ohms respectively. In series with a secondary cell are a coil of 10,000 ohms and two circular rheostats, going up to a total of 10,000 ohms by steps of 1 ohm. Another rheostat of a total resistance of 300,000 ohms, sub-divided in five portions, enables pressure up to 600 volts to be measured. The whole is enclosed in a box, only the handles of rheostats, sliding contacts, keys, &c., projecting ; the parts relative to calibration of the potentiometer against a Clark cell are kept distinct. G. H. B.

1119. *Meter for Three-phase Four-wire Systems.* **H. Aron.** (Elektrotechn. Zeitschr. 22. pp. 215–216, March 7, 1901. Paper read before the eighth meeting of the Verband Deutscher Elektrotechniker at Kiel.)—This paper describes two methods of adapting the Aron meter to read energy on three-phase circuits in which a neutral wire is used. If A, B, C, be the three-line currents, and D the neutral wire current, the equation connecting the line currents takes the form $A + B + C + D = 0$. The author deduces as alternative expressions for the power,

$$W = Ae_1 + Be_2 + Ce_3, \text{ or } = AE_2 - BE_1 - De_3,$$

where, e_1, e_2, e_3, are the voltages between each wire and the neutral, and E_1, E_2, E_3, are those between the three pairs of wires BC, CA, AB, respectively. The former expression can be written $W = Ae_1 + Be_2 - C(e_1 + e_2)$, and the meter is arranged to read this as follows : The two pendulum coils take the voltages e_1 and e_2 ; the former swings over two fixed coils, taking the currents A and C, and wound in opposite directions, so that the pendulum reads e_1 (A — C). The second pendulum swings over the same coil taking C, and a third coil taking B, so that it reads e_3 (C — B); the difference between the rates of the two pendulums then gives the power. To economise space in the meter by placing the middle coil below the other two, the author also arranges the meter to read $W = AE_3 - BE_1 - 1/3D(E_1 - E_3)$, which is deduced from the second expression given above for the power. The pendulum coils then take E_3 and E_1 instead of e_1 and e_3, and the middle fixed coil, instead of taking C, takes D, and is placed below the others at a greater distance from the pendulums. The meter, arranged in either of these ways, is applicable to both star and mesh connections.

G. H. B.

1120. *Direct-Reading Wattmeters.* **H. Armagnat.** (Écl. Électr. 26. pp. 445–446, March 23, 1901.)—The author shows that with alternate current the error due to mutual induction is very small in those direct-reading instruments which have a moving coil. In a particular case, which he considers, he finds the error thus introduced to be less than 0·005 per cent., and in any case he considers it to be so small as to be practically negligible.

W. H. S.

1121. *Phasemeters.* **Armagnat.** (Soc. Int. Élect., Bull. 17. pp. 452–462, Dec., 1900.)—Phase-difference may be defined in different ways: (1) As the time or angle between the passage through zero of the two quantities; this is applicable only when the two curves are similar. (2) As $\cos^{-1} K$, where K is the ratio between the power and the amperes × volts. (3) As the angle ϕ, when $I \sin \phi$ and $I \cos \phi$ are the two components of, say, one current I respectively in phase and in quadrature with the second current.

Teichmuller's phasemeter, made by Siemens and Halske, consists of two rectangular coils fixed at right angles; in the centre of these coils hangs a moving system equivalent to the squirrel-cage of an induction motor; it is constructed of a glass cylinder covered with tin-foil, from which are cut strips parallel to the axis. Two currents out of phase by an angle ϕ, when passed through the two coils, exercise a movement on the squirrel-cage proportional to the sine of the angle. The instrument is adapted for measuring very small phase-differences, from some seconds to about 10 degrees. Arnò's phasemeter is described in Abstract 522 (1901). In Hartmann and Braun's phasemeter the moving system consists of two coils crossing each other at right angles and pivoted on a vertical axis passing through the points where the coils cross. One coil is in circuit with a high self-induction, the other has its resistance adjusted to take the same current at a given pressure and frequency. The system is pivoted within, and at right angles to the axis of, a coil taking the main current (the phasemeter being arranged to measure the phase-difference between the current and the pressure in any circuit). The two moving coils, connected in parallel across the circuit, produce a rotary field, and set themselves in such a position that this field is parallel to the field of the main coil at the moment when the current in it passes through its maximum.

The phasemeter made by the Allgemeine Company measures the phase-angle in accordance with the third definition given above. An aluminium disc controlled by a spiral spring turns between the poles of three electromagnets; the central one takes the main current, and the two extremes are connected across the circuit; a high resistance in series with these ensures the current in them being in phase with the pressure. The torque on the disc is then proportional to the current multiplied by the sine of the phase angle, the pressure being assumed constant. The author in conclusion gives reasons for doubting the accuracy of the indications given by these phasemeters. A bibliography of the subject is appended. G. H. B.

1122. *Induction Coils at the Paris Exhibition.* **H. Armagnat.** (Écl. Électr. 26. pp. 5–15, Jan. 5, 1901.)—Some very large induction coils were shown at the Paris Exhibition—two by Klingelfüss and Max Levy giving 1 m. sparks, and two by Ducretet and Radiguet giving 80 cm. sparks. The German coils have generally a straight cylindrical form with the primary circuit enclosed in an ebonite tube and movable relatively to the secondary; the primary is made considerably longer than the secondary. The Klingelfüss coil, however, has a complete iron circuit consisting of vertical U-shaped stampings, the legs of which take the coils, provided with pole-pieces with a narrow air-gap. The coils are wound by a special apparatus which lays the wires in the insulating medium in such a way that contiguous wires do not touch.

The condensers are generally separate from the coils. Rochefort and Ducretet alone employ liquid insulation; the former connects two secondary coils in parallel, and claims for this method a better spark than with one coil of wire of double the cross-section. With this coil Tirsot was able to signal nearly double the distance possible with an ordinary coil giving the same length of spark.

The circuit-breakers shown are of three types—dry circuit-breakers, those with liquid insulation, and electrolytic. The first are usual only with coils giving less than a 25-cm. spark, and cannot work regularly at a higher pressure than 20 volts. Macfarlane Moore's circuit-breaker has its armature and contact enclosed in a vacuum and worked by an exterior electromagnet; the spark in vacuo is very much reduced. Villard showed two mercury contact-breakers actuated by the movement of a wire, forming part of the circuit, in the gap of a permanent magnet; when current passes in the wire its motion in the gap breaks circuit. A larger type with tuning-fork, making 40 to 45 vibrations per second, is adapted for use with alternate currents; for this the tuning-fork is actuated by a transformed current, while the untransformed current passes through the contact to the coil; by this means the time of contact can be adjusted so that the circuit is broken at the moment of maximum current, while it is made when the current is zero, and the coil therefore receives current impulses in one direction only. A common type of circuit-breaker is one in which a vertical wire is moved in and out of the mercury by an electromotor; this type is not suitable for high frequencies. Gaiffe, by attaching a circuit-breaker at each end of the motor, reaches a frequency of 100 periods. The Allgemeine Elektrizitäts Gesellschaft showed a circuit-breaker in which a turbine driven by an electromotor draws up mercury from a well to a hollow horizontal disc, from the periphery of which it issues in a jet, and falls again into the well; the jet in turning impinges on the teeth of an iron ring, with which it makes and breaks contact. In Max Levy's circuit-breaker, of a similar type, the dented ring is rotated as well as the turbine, and the mercury jet is stationary; in this the time of contact can be adjusted. Ducretet's circuit-breaker consists of a metal disc and a star mounted on the shaft of an electromotor and each dipping in a separate mercury cup. In Hirschmann's type contact is made by one copper strip sliding over another fixed strip, each being amalgamated to ensure good contact with little friction. Siemens and Halske showed a Wehnelt circuit-breaker with water-cooling to enable it to be worked continuously at a pressure above 50 volts. On the other hand, Carpentier showed a model with felt lagging to allow working at low voltages. G. H. B.

1123. *Three Forms of Thomson Bridge for Measuring Low Resistances.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 22. pp. 157–158, Feb. 14, 1901.) —In this paper the normal type of Thomson bridge with Uppenborn's shunt is first described, after which three constructional forms are explained. The first is a bridge for instructional use, in which the standard wire and graduated scale are 80 cm. long and the knife-edge contacts at both ends thereof are adjustable; the distance between the fixed knife-edge contacts for the bar to be tested is also 80 cm. In the second bridge described, which is of the Uppenborn type (see Centralblatt für Electrotechn. 1886, p. 289), the standard wire and graduated scale are 1 metre long. Finally, a workshop form is described, in which the distance between the knife-edges for the bar to be tested is adjustable by securing one pair of knife-edges at different points along bars, which are themselves capable of being adjusted by hand levers relatively to a fixed pair of knife-edges. The movable contact for the slide wire is mounted on a carriage provided with wheels running on a prismatic rail. Diagrams of the connections and photographs of the apparatus are given in the original paper. C. K. F.

1124. *Alternate-current Measurement by Electrometers.* **G. L. Addenbrooke.** (Electrician, 45. pp. 901–903, 1900. Abstract of paper read at the International Electricity Congress, Paris, 1900.)—The author has adapted his electrometer [Abstract No. 864 (1900)] to the measurement of alternating pressure, current, and power. Three instruments are employed: a voltmeter, reading up to about 100 volts; an ammeter, consisting of an electrometer reading up to about 2 volts, and arranged to measure the drop of volts across a known resistance; and a wattmeter, in which the two pairs of quadrants are connected across a resistance through which the current passes, while the needle is connected to the other side of the circuit, so that the potential difference of the circuit is established between the needle and quadrants. By adjusting the distance between the quadrants, the instruments can be made direct-reading. The wattmeter reads proportionately within one-half of 1 per cent. over a range of 200 m. (scale at 2 metres) and within 1 per cent. over 300 m. The ammeter electrometer, on account of its greater sensitiveness, does not give so exactly proportionate a scale. The three instruments are arranged as follows: To a bus-bar, forming one terminal of the source of power, are connected one pair of quadrants of the wattmeter and the quadrants of the ammeter and voltmeter, a standard cell, a battery in series with an adjustable resistance, a potentiometer resistance of 100,000 ohms, and the current-measuring resistance. The voltmeter needle is connected to the centre of a four-way switch, of which one point forms the second terminal of the source of power, a second and third are connected to the other end and to the moving contact of the potentiometer resistance, and the fourth point short-circuits the instrument. The needle of the wattmeter is connected to the centre of an exactly similar switch. The needle of the ammeter and the second pair of quadrants of the wattmeter are connected to two other four-way switches, with contacts as follows: One connected to the current measuring resistance, one to the Clark cell, one to the moving contact of the potentiometer resistance, and one short-circuiting the instrument. Between each pair of contacts on the four switches is an intermediate passing contact, short-circuiting the instrument through a resistance of 20,000 ohms; this is to avoid the sudden deflections which may occur on the break of circuit in passing from one contact to another. With these arrangements the instruments can all be calibrated in terms of the Clark cell and the current measuring resistance; the methods of calibration are fully described in the paper. G. H. B.

1125. *Condenser of Adjustable Capacity.* **G. Ercolini.** (N. Cimento, 12. pp. 279–280, 1900.)—Brigg's adjustable condenser [see Abstract No. 2223 (1900)] made of flexible mica plates subjected to varying pressures, gives a wide range of capacities, but is open to the objection that the variation of capacity with pressure follows an unknown law, and is not always a certainty. The author has, therefore, improved upon it by substituting glass plates for the flexible plates. The glass plates are mounted one above the other on metallic rails laid into an ebonite scaffolding. The scaffolding can be sheared like a parallel ruler, so that the glass plates can be made to approach each other to any extent desired. Sheets of tin-foil stuck on both surfaces serve as the metal plates. The capacity varies with the cosine of the angle of inclination of the guiding rod. The condenser can, of course, be used as an air-condenser, or immersed in a liquid. E. E. F.

1126. *Alternating Current Wave Recorder.* **F. A. Laws.** (West. Electn. 28. p. 128, Feb. 23, 1901. Also Amer. Acad., Proc. 36. pp. 321–324, Jan., 1901.) —This arrangement of apparatus is a modification of the "contact method," and gives a continuous record which is traced photographically. It is a device for obtaining the average wave and is unsuitable for recording transient phenomena. Two rigidly connected contact wheels of ebonite are driven by means of a synchronous motor. By means of worm gearing the brushes are made to move uniformly round the contact wheels, the ratio of reduction being 7,200 to 1. A spot of light from a Sullivan universal galvanometer is focussed on a camera and the photographic plate is moved vertically by means of a fine wire wound on a drum. The time taken for recording a wave when the frequency is 120 is 1½ minutes. Examples are given of records of pressure and current waves in various interesting cases. A. R.

ALTERNATING CURRENTS AND MAGNETISM.

1127. *Direct Tracing of Alternating Curves.* **A. Blondel.** (International Physical Congress at Paris, Report, 3. pp. 264–295, 1900.)—The report begins with an historical survey of the gradual development of the direct methods of recording the shapes of the waves of alternating currents and e.m.f.'s. The author describes three forms of oscillographs: (1) The bifilar, (2) the vibrating strip, and (3) the vibrating plate oscillograph. The principle of all these instruments is founded on the general equation for dead beat galvanometers, namely—

$$K\frac{d^2\theta}{dt^2} + A\frac{d\theta}{dt} + T.\theta = GI \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where K is the moment of inertia of the moving parts, A the damping coefficient, T the couple of torsion, G the galvanometer constant, and I the current. In order that I may be proportional to θ, the first two terms of this equation must be negligible. The author concludes that a good instrument must fulfil the following conditions:—

(1) The free period of oscillation of the instrument must be less than the

fiftieth part of the period of the required current curve. (2) The damping must be adjusted until the instrument just becomes dead beat. (3) The self-inductance of the instrument must be so small that its effect on the shape of the wave is negligible. (4) Hysteresis and eddy currents must be negligible. (5) It must be very sensitive, and hence the moving parts must be minute.

The author describes the modifications he has introduced into the latest form of his bifilar oscillograph. These improvements were for the most part suggested by an exhaustive theoretical consideration of the problem. For example, he considers the two bands rigidly connected at the middle by a mirror as forming a solid, and applies Saint-Venant's method to find the period of the torsional vibrations. He gives the solution in full, and points out that it shows (1) that $\frac{T}{\sigma}$ should be large, where T is the tension of either band, and σ is the area of its cross-section; (2) that the bands should be square or round; and (3) that $\frac{\rho}{E}$ should be made as small as possible by choosing a suitable metal where ρ is the specific gravity of the metal and E its coefficient of elasticity. The author now uses round or square aluminium rods of very small section for suspending the mirror. He has reduced the period of vibration to between the ten thousandth and fifteen thousandth part of a second, and the sensitivity of the instrument is such that a current of 1 ampere produces a deflection of 80 centimetres when the scale is 1 metre from the mirror. He adopts Ewing's conical poles in order to get a strong field, and has an air-gap of only about 0·6 to 1 millimetre.

In the latest form of his vibrating strip oscillograph he uses an iron strip about 0·2 to 0·3 millimetre broad and a few hundredths of a millimetre thick, stretched vertically in the magnetic field, and carrying a little mirror at its centre. This band is enclosed in an oil case containing a lens. Each element of the band behaves like a little magnet, and the deviation increases from the ends to the middle of the band, where it is a maximum, the total deviation being proportional to the current. A free period of the fifty thousandth part of a second can be obtained by this arrangement. For industrial purposes the author states that these oscillographs are the best, and they can be made double or triple so that pictures of two or three curves can be thrown on the screen at once. Oscillographs play the same part in alternating current work that Watt's indicator does for the steam engine, and their precision is very much greater. They have been successfully employed in practical industry in France by the firms of Farcot and Bréguet.

Another method of getting the shape of alternating current waves is by the rheograph of Abraham. In this instrument, which is a kind of galvanometer, the free vibrations of the moving parts are less rapid than the alternations of the current to be examined. The inertia and damping, however, are compensated by means of electromagnetic induction. A current which is defined by the equation—

$$i = k\frac{d^2I}{dt^2} + a\frac{dI}{dt} + tI,$$

where I is the current to be studied, is passed through the galvanometer; then by equation (1) we see that I will be exactly proportional to θ if we make—

$$\frac{k}{K} = \frac{a}{A} = \frac{t}{T}$$

He attains this result by making use of four coils so as to get mutual induction effects between them.

The author states that this method is the most ingenious of the direct methods, and neither damping nor inertia limit its application. The only drawback is that the coils introduce a certain amount of inductance in the circuit, and this may alter the shape of the wave we have to measure. It is said that it can be used to record the shape of waves having a period of only the ten thousandth part of a second—a result quite out of the question with an oscillograph.

What the author calls the "oscilloradiograph" of Braun makes use of the deviation of the rays produced in a kathode tube excited by the alternating current whose wave form is desired. At present this method is most imperfect because the apparatus required is very complicated and the curve traced lacks precision. A certain amount of inductance is also brought into the current circuit, and this may alter the current wave. This method may be useful for tracing wave shapes at very high frequency, as the rays seem to be deflected instantaneously without any apparent inertia effect. A. R.

1128. *Effect of Aluminium Valves on Current Curves.* **G. Mayrhofer.** (Elektrotechn. Zeitschr. 21. pp. 913–915, and 926–929, 1900.)—To study the influence of an aluminium cell upon the curves of an alternating current, a Braun kathode-ray tube was used, and the displacements of the beam were drawn out and photographed by means of a revolving mirror. The effect depends upon the current density, the e.m.f., and the electrolyte used in the aluminium cell. Potassium bichromate is more effective as a rectifier than alum, especially at low voltages, but at higher voltages it shows a great tendency to produce luminosity of the electrodes. It is more profitable to employ a single effective cell than to join several less effective ones in series. Some examples of curves are given in the accompanying diagrams, where Fig. 1 represents an unmodified curve, Fig. 2 a curve produced by using a very small aluminium electrode with an e.m.f. of 25 volts, and a current density of 0·3 amperes per sq. cm., and Fig. 3 by using a somewhat stronger

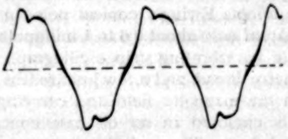


FIG. 1.

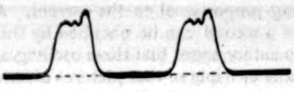


FIG. 2.

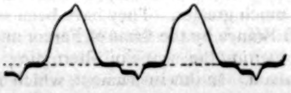


FIG. 3.

current. The author describes a beautiful acoustic experiment, in which the pitch of a vibrating iron armature is lowered by an octave on introducing an aluminium valve. E. E. F.

1129. *Direct Method of Harmonically Analysing Alternate Currents.* **T. des Coudres.** (Elektrotechn. Zeitschr. 21. pp. 752–755, and pp. 770–772, 1900.)—The principle of this method will be found explained in Abstract No. 1085 (1899). The present paper contains an account of some experimental investigations carried out in order to test the practical value of the method. The author finds that the accuracy of the method exceeds that of methods in which the actual shape of the current-wave is traced. The sine-inductor used consisted of two fixed solenoids placed end to end, which acted as field magnets, giving rise to a uniform field. In this field was rotated a small circular coil, 2 cm. in diameter and 1 cm. wide, wound with 500 turns of silk-covered wire 0·3 mm. in diameter. By means of variable toothed gearing the coil could be driven from the alternator shaft at any required multiple of the speed of synchronism. An ordinary torsion wattmeter, constructed by Ganz & Co., was used for measuring the mean couple due to the interaction of the current under test and the current furnished by the sine-inductor. A. H.

1130. *Trend of the Horizontal Component of the Earth's Magnetic Field in France.* **E. Mathias.** (Comptes Rendus, 132. pp. 320–322, Feb. 11, 1901.)—This is a continuation of the paper referred to in Abstract No. 146 (1901). The author has continued his calculations, and now considers that the formula given in the previous Abstract ought more correctly to be—

$$\Delta H = -1{\cdot}16\,(\Delta\ \text{long.}) - 7{\cdot}32\,(\Delta\ \text{lat.}).$$

He finds that this expression gives the value of H at undisturbed stations for the epoch January 1, 1896, not only throughout France, but also for many stations in the neighbouring countries. W. W.

1131. *Testing Magnet Steel.* **I. Klemenčič.** (Ann. d. Physik, 4. 2. pp. 316–322, Feb., 1901.)—The usual method is somewhat rough and ready; it consists in magnetising, exposing to repeated shocks, and finding the amount of decrease in the magnetic moment. This may serve in cases where the magnet is intended to undergo vibration; but where the desideratum is a constant moment in a state of rest the principal cause of changes in the moment is variations in the temperature, and testing the steel for this involves extending the tests over a long time. The kind of steel which is best for the one purpose is by no means necessarily so for the other. Experimental data are given. In general, at rest magnets with smaller coercitive forces give better results, so that soft iron makes the most constant permanent magnet, its residual magnetism being astonishingly constant so long as no shock or vibration occurs. A. D.

1132. *Magnetic Mirror Images.* **H. Jaeger.** (Ann. d. Physik, 4. 2. pp. 345–366, Feb., 1901.)—The investigation bore first upon the screening action of iron plates in a magnetic field. The magnetic field examined was that of a straight current. Magnetometry was not possible, and the method adopted was that of rotating a coreless coil in a constant field, checked by using the coil at rest in the field of a varying current. The percentage of screening action increases as the primary current diminishes. The field of a straight current lying upon a sufficiently large and soft iron plate is doubled through the presence of the iron, as if there had been a similar current similarly situated within the surface of the iron, a kind of magnetic virtual image. The amount of strengthening of the field may fall short of this doubling, according to the breadth and the hardness of the iron and the strength of the current. Comparative tests were made with a real current in the place of the virtual current; and solenoids were now employed instead of straight wires. Optical analogies were pursued with success, in respect of virtual images produced by inclined mirrors and kaleidoscopic effects. A. D.

1133. *Magnetic Balance.* **G. Guglielmo.** (Archives Néerlandaises, 5. pp. 175–180, 1900.)—The author at the commencement of 1900 described an areometer devised by him, consisting of an asymmetric mass immersed in the liquid, with one end (provided with a suitable knife-edge) resting against a horizontal glass plane, either above or below, according to whether the areometer be heavier or lighter than the liquid.

By attaching a bar magnet the areometer becomes a magnetic balance of extreme sensibility, and its movements may be observed by a mirror and scale. The author describes the methods he has employed to determine the horizontal and vertical magnetic components, but he has not compared his determinations with measurements made by a magnetometer. Variations of temperature have considerable influence on the measurements. G. H. B.

1134. *Design of Electromagnetic Mechanisms.* **W. W. Soubbotine.** (Russian "Electrotechnical Courier," 7. pp. 586–590, Dec., 1900.)—Referring to an article of S. P. Thompson's in the New York Electrical Review, the author points out that the expression there given for the pull exerted by an electromagnet, viz.—

$$f = i\frac{d\psi}{dx},$$

where i is the current, ψ the magnetic flux, and x the displacement, is not correct, and represents *double* the actual pull. He then proceeds to develop a general theory applicable to all electromagnetic mechanisms as follows: Let $p = -f$ be the value of the external force which is necessary to keep a given electromagnetic system in equilibrium (the system may be subject to any given kinematical constraints; p in that case denoting the force required to balance that component of the total force due to the interaction of the various portions of the system, which acts in the direction of the displacement); let L = inductance of the system. Then the total work done on the system by the external force p when a small displacement dx is given to the system in the direction of p is—

$$dw_1 = pdx = -fdx,$$

part of which work will be converted into electrical energy, given by the equation—

$$\begin{aligned} dw_2 &= eidt = -\frac{d(Li)}{dt}idt \\ &= -i^2\frac{\partial L}{\partial x}\cdot\frac{dx}{dt}dt = -i^2\frac{\partial L}{\partial x}\cdot dx, \end{aligned}$$

where e is the e.m.f. induced in the circuit by the displacement; while the remainder, given by—

$$dw_3 = \frac{\partial w_3}{\partial x}dx,$$

will go towards increasing the potential energy w_3 of the system. By the conservation of energy, we have—

$$dw_1 = dw_2 + dw_3,$$

i.e.—

$$-fdx = -i^2\frac{\partial L}{\partial x}dx + \frac{\partial w_3}{\partial x}dx,$$

whence—

$$f = i^2\frac{\partial L}{\partial x} - \frac{\partial w_3}{\partial x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

It remains to calculate the potential energy w_3 of the system. The e.m.f. induced in the system when x is maintained constant and i undergoes an infinitesimal change is given by—

$$e' = -\left(\frac{d(Li)}{dt}\right)_{x=\text{const.}} = -\left(i\frac{\partial L}{\partial i}\cdot\frac{di}{dt} + L\frac{di}{dt}\right) = -\left(i\frac{\partial L}{\partial i} + L\right)\frac{di}{dt}$$

and the work done in increasing the current is—

$$e'idt = -(i^2\frac{\partial L}{\partial i} + iL)di.$$

Hence the total potential energy corresponding to an increase of current from zero to the value i is given by—

$$w_3 = -\int_i^0 (i^2\frac{\partial L}{\partial i} + iL)di = \int_0^i (i^2\frac{\partial L}{\partial i} + iL)di = \int_0^i (i^2\frac{\partial L}{\partial i}di + \int_0^i iLdi \ldots\ldots (2)$$

Integrating the first of these two integrals by parts, we get—

$$\int_0^i i^2\frac{\partial L}{\partial i}di = \int_0^i i^2dL = Li^2 - 2\int_0^i iLdi.$$

Substituting this in equation (2), we get—

$$w_3 = Li^2 - \int_0^i iLdi,$$

so that—

$$\frac{\partial w_3}{\partial x} = i^2\frac{\partial L}{\partial x} - \frac{\partial}{\partial x}\int_0^i iLdi = i^2\frac{\partial L}{\partial x} - \int_0^i i\left(\frac{\partial L}{\partial x}\right)di,$$

and hence, using (1)—

$$f = \int_0^i i\left(\frac{\partial L}{\partial x}\right)di \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The author then proceeds to apply this general formula to various special cases. A. H.

REFERENCES.

1135. *Electric Waves.* **J. A. Fleming.** (Soc. Arts., Journ. 49. pp. 69–84, Dec. 28, 1900; 86–95, Jan. 4; 97–112, Jan. 11; and pp. 113–131, Jan. 18, 1901.)—A course of four Cantor Lectures entitled respectively, Electric Oscillations, Electric Resonance, the Electromagnetic Medium, and Electric Waves. The subject is here presented in a semi-popular manner, but with such fulness of illustration and references to the authorities concerned as to make the articles a very valuable *résumé* of the ground covered. E. H. B.

1136. *Hysteresis.* **E. Warburg.** (International Physical Congress at Paris, Report, 2. pp. 509–531, 1900.)—The author deals with (1) The history of the subject, including hysteresis of field, of deformation, and of temperature. (2) Pseudo-hysteresis of dielectrics. (3) Analogy of mechanical strain. (4) Various factors affecting hysteresis. (5) Ewing's theory. (6) Change in properties of iron at 800°, and Osmond's theory. (7) Hysteresis of pure iron. The paper is followed by an appendix by van't Hoff. [See Abstract No. 1165 (1901).] P. E. S.

1137. *Theory of Electric Induction.* **G. Bakker.** (Archives Néerlandaises, 5. pp. 312–321, 1900.)—A mathematical paper which claims to give a more direct and complete proof of certain electromagnetic equations than that due to Maxwell. The equations are a cyclical set of three, of which only one is here given, viz. :—

$$P = H_z \frac{dy}{dt} - H_y \frac{dz}{dt} - \frac{\partial F}{\partial t} - \frac{d\psi}{dx},$$

where F, G, and H are the components of a vector whose integral along a circuit multiplied by the intensity of the current, gives the potential energy with respect to the electromagnetic field; and H_x, H_y, and H_z are the components of a vector, of which the integral over the area of the surface of the circuit equals that just named; finally P, Q, and R are the components of a vector whose line integral along the circuit gives the induced e.m.f. E. H. B.

1138. *Influence of Ferromagnetic Crystals.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 3. pp. 331–344, 1900.)—This paper treats of the subject mathematically and cannot be well abstracted. The observations of P. Weiss on magnetite, published in a thesis presented to the Faculty of Science of Paris in 1896, are especially dealt with. T. H. P.

1139. *Contact Electricity.* **C. Christiansen.** (International Physical Congress at Paris, Report, 2. pp. 390–402, 1900.)—A clear and comprehensive summary of the results obtained and theories advanced by experimenters in the subject, from the time of Volta up to the date of the Congress. J. E.-M.

1140. *Mode of Propagation of Energy and Electric Tension in the Electromagnetic Field.* **J. H. Poynting.** (International Physical Congress at Paris, Report, 2. pp. 284–300, 1900.)—A discussion of the nature of the electromagnetic field existing around conductors traversed by a current. The ideas of Faraday and Maxwell are extended so as to explain the behaviour of the energy and electric tension when the system is not in equilibrium. The medium surrounding the conductor is regarded as the chief seat of the action. Among the subjects discussed are the localisation and transference of energy, electromagnetic waves, discharge of condenser, circuit containing a battery, and the movement of tubes of force and electric tension. D. E. J.

1141. *Currents of High Tension and Great Frequency.* **Molloy.** (Elect. Rev. 48. pp. 37–38; Discussion, p. 38, Jan. 4, 1901.)—Abstract of a paper read before the Dublin Section of the I.E.E.

1142. *Striæ in Geissler Tubes.* **E. Riecke.** (Ann. d. Physik, 4. 2. pp. 388–401, Feb., 1901.)—A paper similar to that referred to in Abstract No. 852 (1901), but of greater length. J. B. H.

1143. *Recent Researches on Atmospheric Electricity.* **F. Exner.** (International Physical Congress at Paris, Report, 3. pp. 415–437, 1900.)—A summary of recent investigations on the daily and annual variations of atmospheric electricity, the variation of the field at different heights, and other problems in this subject; followed by a discussion of the different theories propounded, and mention of the points which still require to be cleared up by experiment. W. C. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1144. *Intimate Structure of Crystals. Cubic Crystals with Octahedral Cleavage.* **W. J. Sollas.** (Roy. Soc., Proc. 67. pp. 493–495, Feb. 5, 1901.)—*Diamond.*—Carbon, m.w., 12 ; sp. gr., 3·51 ; m.v., 3·42. Each atom is in the closest contact with twelve others in planes normal to the trigonal axes of the cube which they are supposed to form. The volume of the atoms is found by dividing the atomic volume by 1·35 ; it is 2·54 ; the diameter of the atom is 1·693, and its gross volume 4·851. The atoms lie closest in planes parallel to the faces of an octahedron, hence the cleavage. Diamond is tetrahedral : the hemihedry may be accounted for by the grouping of the atoms, or by a tetrahedral nature in the carbon atom itself, the constituent tetrahedra in both cases being all similarly orientated. The author refers to Barlow (Sci. Proc., R. Dubl. Soc., viii. 533, 1897). He next gives a comparison with graphite. A specimen obtained in the manufacture of carborundum was introduced into a diffusion column of methylene iodide and benzene ; and floated at a level of sp. gr. 2·286, as given by small glass indicators. The value deduced from this is m.v. 5·25 ; Petersen (Zeit. Phys. Chem. viii. 601 1891) obtained 5·3. The crystalline form is now considered to be monoclinic. If a number of tetrahedral groups of atoms be placed each with a trigonal axis vertical, the atoms at the base forming a single sheet in close contact, and a similar sheet be superposed with vertical axes continuous with the lower ones, the resulting symmetry will be oblique and hemimorphic. The volume of the packed spheres in the case of the diamond will be to that in graphite as 2 to 3, corresponding to the ratio between the molecular volumes, 3·42 to 5·25. This structure in graphite would be a loose one, and would approach closely to the symmetry of the rhombohedral system, accounting for the softness and for the crystallographic form. [See further Abstract No. 144 (1899).] S. R.

1145. *Nernst's Formulæ for the E.M.F.'s of Concentration-Cells.* **H. Jahn.** (Zeitschr. Phys. Chem. 36. pp. 453–460, March 12, 1901.)—The author replies to Arrhenius' objection [see Abstract No. 908 (1901)], namely, that Nernst's formulæ are inexact, owing to the fact that ions passing from one solution to another of different concentration do not necessarily remain as ions except in very dilute solutions. Jahn points out that Nernst's formulæ are obtained by calculating the net changes of free energy occurring in the process under consideration. As the state of any layer of solution will always be indefinitely near the state of equilbrium between ions and non-ionised salt, there are no changes of free energy attending the combinations or dissociations of ions caused by electrolytic conduction, and therefore it would be quite erroneous to correct Nernst's formulæ for the reason given by Arrhenius. It is further pointed out that Nernst's formula can be deduced from that of Arrhenius, if the law of mass-action for the ionic equilibrium be assumed, and the statement is made that the three equations (1) Nernst's formula ; (2) Arrhenius's formula ; (3) Ostwald's "dilution" law, are so related that any one can be deduced from the other two. Hence the ionic concentrations calculated by Jahn, since they satisfy (1) and (3) must satisfy (2), so that Arrhenius's criticism recoils on himself. F. G. D.

1146. *Mixtures of Hydrochloric Acid and Methyl Ether.* **J. P. Kuenen.** (Archives Néerlandaises, 5. pp. 306–311, 1900.)—Mixtures of these two substances are interesting, since it follows from Friedel's work on the subject that they exhibit a maximum of B.Pt., and therefore a minimum of vapour-pressure. The object of the present investigation was to trace this minimum up to the critical region, and to obtain a complete pressure temperature diagram. This programme could not, however, be completely carried out, since even at temperatures below 100° C. irreversible chemical action occurs, with the production chiefly of methyl chloride and water. Nevertheless the following facts could be ascertained :—

(1) The mixtures have a minimum vapour-pressure in accordance with what could be derived from Friedel's experiments. This minimum exists up to the critical condition.

(2) Addition of hydrochloric acid raises the critical point of methyl ether.

A pressure-temperature diagram is given showing the results obtained. The author points out that the production of a liquid boiling much higher than methyl ether does not prove the formation of a double compound, since a high value for the mutual attraction constant, a_{12}, in van der Waals' equation would sufficiently account for the result. Even the abnormal vapour density is not a perfectly certain criterion. F. G. D.

1147. *Equilibrium between Ester, Water, Acid, and Alcohol.* **H. Euler.** (Zeitschr. Phys. Chem. 36. pp. 405–412, March 12, 1901. From the Öfversigt af K. Svenska Vetenskaps-Akadem. Förhandl., 1900, No. 9.)—The hydrolysis-equilibrium in acid solution is investigated in the case of the methyl, ethyl, and propyl esters of acetic, propionic, formic, and chloracetic acids, and it is found that the degree of hydrolysis of an ester *increases* with the strength of the acid, which is contrary to what would be expected if an ester be regarded as an *ionisable* salt in which the alcohol plays the part of the basic constituent. If, however, it be supposed that the alcohol can act as the acidic constituent, *i.e.*, if, for example, ethyl acetate be regarded as a salt-like compound which ionises in *both* the following ways,

$$\mathrm{CH_3\overset{+}{C}O : O\overset{-}{C}_2H_5,\quad \overset{+}{C}_2H_5 : CH_3\overset{-}{C}OO,}$$

then it can be shown by considering the various possible equilibria that the *increase* of hydrolysis with *increase* in the dissociation-constant of the generator acid is possible. In conclusion the author points out that the view that the hydrolysis of an ester occurs chiefly in the former of the two ways indicated above, is in complete agreement with the conclusions deduced by van't Hoff (Zeit. Phys. Chem. 13. p. 493, 1893), from a study of the velocities of saponification, and of hydrolysis in acid solution of various esters.

F. G. D.

1148. *Solubility of Metallic Precipitates Determined Electrolytically.* **C. Immerwahr.** (Zeitschr. Elektrochem. 7. pp. 477–483, Feb. 28, 1901.)—From the potentials of metallic electrodes immersed in saturated solutions of their salts, especially those of very slight solubility, the concentration of the metallic ions and the solubilities of such salts may be calculated. The method affords the best means of determining the solubility of the more insoluble salts, which are of importance in qualitative chemical analysis. Mercury, copper, lead, zinc, and cadmium compounds have been experimented with, and the results obtained are given in tabular form. N. L.

1149. *Change of Free Energy in the Formation of Some Difficultly Soluble Salts.* **A. Klein.** (Zeitschr. Phys. Chem. 36. pp. 361–371, Feb. 22, 1901.)—The author has measured the e.m.f.'s at different temperatures, and hence determined the temperature-coefficients of e.m.f. for various cells constructed according to the scheme :

$$\mathrm{M},\ [\mathrm{MX}'_n],\ \frac{n}{100} - \mathrm{KX}',\ n - \mathrm{KNO_3},\ \frac{n}{100} - \mathrm{KX}'',\ [\mathrm{MX}''_n],\ \mathrm{M}$$

where M may be Pb, Cu′, or Ag, and X may be Cl, Br, I, or SO_4. The square brackets indicate the *solid* (difficultly-soluble) "depolariser." In this way are obtained the decrease of free energy, and the variation of the total energy (heat of reaction) for the following reactions, supposed to take place in complexes which are $\frac{n}{100}$ with respect to the "soluble" salts :—

1. $[PbCl_2] + 2KBr \rightarrow [PbBr_2] + 2KCl$
2. $[PbBr_2] + 2KI \rightarrow [PbI_2] + 2KBr$
3. $[PbCl_2] + 2KI \rightarrow [PbI_2] + 2KCl$
4. $[PbCl_2] + K_2SO_4 \rightarrow [PbSO_4] + 2KCl$
5. $[PbBr_2] + K_2SO_4 \rightarrow [PbSO_4] + 2KBr$
6. $[PBI_2] + K_2SO_4 \rightleftarrows [PbSO_4] + 2KI$
7. $[CuBr] + KI \rightarrow [CuI] + KBr$
8. $[AgCl] + KBr \rightarrow [AgBr] + KCl$
9. $[AgBr] + KI \rightarrow [AgI] + KBr$
10. $[AgCl] + KI \rightarrow [AgI] + KCl$

Substances not in square brackets remain *in solution*. The arrow indicates the direction in which the double decomposition takes place in the temperature-region investigated (0–40° C.). A very interesting case is afforded by reaction No. 6. Here the reaction proceeds from left to right if the temperature be greater than 8° C., in the opposite direction if the temperature be below that value.

The reactions 4, 5, and 6 (from left to right, *i.e.*, at temps. $> 8°$ C.) are found to be *endothermic*, and are therefore specially interesting as examples of endothermic reactions occurring at "ordinary" temperatures. The reaction 6 is exothermic or endothermic according as the temperature is below or above 8° C. It must not be forgotten that these reactions occur in presence of solutions of definite specified concentrations. For experimental details the original must be consulted. The usual methods of measuring e.m.f. were employed. The solutions were all normal with respect to KNO_3 in order to reduce the p.d.'s at the liquid junctions to a minimum. F. G. D.

1150. *Polarisation of Voltameters.* **G. di Ciommo.** (N. Cimento, 12. pp. 258–279, 1900.)—A new method is used for measuring the polarisation of a silver voltameter immediately after the passage of a current impulse. The results show a distinct polarisation of silver electrodes immersed in nitrate of silver. The laws obeyed by the polarisation in question are the following : The e.m.f. of polarisation is only a function of the quantity of polarising electricity. It equals the sum of the polarisations of the two electrodes, and these polarisations are equal if the electrodes have equal areas. The e.m.f. of polarisation is inversely proportional to the area of the electrodes, for the same quantity and temperature. As regards the dependence of the e.m.f. of polarisation, E_0 upon the quantity of electricity, E_0 increases at first with Q, then the increase becomes more gradual, and at a certain value of Q a diminution sets in, rapid at first, and then more and more gradual. Heating diminishes E_0. The film which covers silver in air, whatever its nature, increases the value of E_0.

E. E. F.

1151. *Liquefaction of a Mixture of Two Gases.* **P. Duhem.** (Journ. Phys. Chem. 5. pp. 91-112, Feb., 1901.)—If a mixture of two gases at constant temperature T be subjected to increasing pressure, the system consists of two phases, liquid and vapour, while the pressure varies between two values, for one of which the mixture is all liquid, and for the other of which it is all gas, and provided that T does not correspond to a Gibbs-Konowalow point. The author studies the variations with pressure of the concentrations of these phases. He proves that, if through a point (T, π) within the limiting line of a mixture of mean concentration X there pass a single dew line (for mean concentration *s*) and a single boiling line (for mean concentration S), then for pressure π and temperature T the mixture of mean concentration X will consist of a liquid phase of concentration S, and a vapour phase of concentration *s*. Unless the system possesses a Gibbs-Konowalow line, two distinct boiling or dew lines cannot pass through the same point. If the system possesses one or more Gibbs-Konowalow lines, there may pass through a point (T, π) several dew and several boiling lines. To distinguish which of these are the *useful* dew and boiling lines, the author proves many properties of these sets of lines, and demonstrates the possibility of studying the changes of composition of the liquid and its vapour during isothermal compression by drawing a sufficiently fine network of limiting lines. The cases in which retrograde condensation and vaporisation respectively occur are particularly investigated. W. E. T.

1152. *Potential Change in Oxidation Chains.* **K. Schaum.** (Zeitschr. Elektrochem. 7. pp. 483-484, Feb. 28, and 523-524, 1901.)—In the course of the author's investigations of concentration cells containing an oxidising agent and the product of its reduction [see Abstract No. 1227 (1899)] sulphite-sulphate cells were also examined as being an example of chains, in which the oxidising and reducing agents formed non-isomeric ions. Their behaviour was found to be greatly influenced by the addition of a few drops of benzyl alcohol, the reaction $\overset{--}{SO_3} + \overset{--}{O} \rightleftarrows \overset{--}{SO_4} + 2(-)$ being thereby accelerated, and the cell rendered reversible and analogous to the ferrocyanide-ferricyanide system previously described. N. L.

1153. *Method of Comparing the Affinity Values of Acids.* **H. J. H. Fenton** and **H. O. Jones.** (Chem. Soc., Proc. 17. pp. 24-25; Discussion, p. 26, Feb. 15, 1901.)—When the hydrazone of oxalacetic acid is heated with water it undergoes decomposition to the extent of 83-90 per cent., the exact number depending on the purity, the products being the hydrazone of pyruvic acid and carbon dioxide. In the presence of sufficiently concentrated acids, however, no carbon dioxide is given off, but water is lost and the pyrazolone carboxylic acid of Wislicenus formed. Parallel experiments with different acids show that the volumes of carbon dioxide obtained are in the inverse order of the affinity-values of the acids. In explanation of this behaviour, the authors suggest that the undissociated molecule of the hydrazone tends only to lose water giving the pyrazolone derivative, but that the negative ion $CO_2H.CN_2HPh.CH_2CO_2$ is unstable, and tends to lose carbon dioxide. According to this hypothesis, any circumstance tending to prevent ionisation should favour the production of the pyrazolone derivative, while the presence of a sufficient concentration of hydrogen ions should cause the change to take place in this direction more or less completely. A series of experiments has hence been carried out to determine the influence on the reaction of various salts, non-electrolytes, acids in presence of the corresponding salts, and solvents other than water. The results, which are, on the whole, well in harmony with the ionisation hypothesis, lead to the following conclusions: (1) The influence of salts, bases and non-electrolytes is *nil*, the results being practically identical with that given by pure water. (2) The effect of a salt in presence of its acid is to greatly diminish the influence of the acid. (3) Solvents having different ionising powers give very different results, the amount of carbon dioxide evolved being greatest in the case of water, less for amyl alcohol, and least for toluene and nitrobenzene. T. H. P.

1154. *Relation between the Specific Volumes of Coexisting Fluid Phases.* **J. D. van der Waals.** (Archives Néerlandaises, 5. pp. 407–416, 1900.)—The assumption that the potential energy of a normal substance is completely determined by the work done against surface tension leads to the relation $(dv_1/dt)/\beta_1 + (dv_2/dt)/\beta_2 = 0$, where v_1 and v_2 are the specific volumes of the co-existing fluid phases at the temperature t, and β_1, β_2 are their compressibilities. Calculations in regard to ether show that this relation posseses a high degree of approximation. If it is exact, the molecular pressure is strictly of the form $av^{-2} f(t)$. R. E. B.

1155. *Conductivity of Solid Electrolytes at High Temperatures.* **W. Nernst** and **H. Reynolds.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 3. pp. 328–330, 1900).—The substance, in the form of thin rods, was heated in a platinum oven, consisting of a thin tube of magnesia with 10 per cent. steatite, wound round with platinum wire, the winding being plastered over with magnesia. The temperature was determined by a thermo-couple. Contact was made at four points of the rod, and three readings taken on a Kohlrausch bridge so as to eliminate the contact resistances. Pure oxides have exceedingly high resistances. The specific conductivity of MgO at 1,500° C. is 0·000085; of LaO_2 at 1,200°, 0·00081; Y_2O_3 at 1,320°, 0·082, while at 1,040° it insulates completely. Mixtures, however, conduct comparatively well, and curves are given showing the increase of conductivity for various mixtures. Mixtures of Thoria, Zirconia and Ceria conduct badly, as also do mixtures of Yttria and Erbia. Mixtures between these two groups, however, conduct relatively well. [See further Abstract No. 1910 (1899).] G. H. B.

1156. *Electrolytic Alkaline Periodates.* **E. Müller.** (Zeitschr. Elektrochem. 7. pp. 509–516, March 21, 1901.)—Perchlorates can be prepared by electrolysing neutral chlorate solutions without a diaphragm in the cold, but under similar conditions an iodate is reduced quantitatively to the iodide at the kathode, whilst at the anode a partial reoxidation of the iodide to the iodate occurs. The reduction at the kathode can be very much diminished by adding a small proportion of potassium chromate to the neutral solution. In a divided cell periodates can be produced in considerable quantity, the essential conditions for a good yield (up to about 26 per cent.) being a low temperature, low current-density, and at least 4 per cent. of caustic alkali in the solution. T. M. L.

1157. *Electrolysis of Phenol in Presence of Hydrogen Chloride, Bromide, and Iodide.* **H. Zehrlant.** (Zeitschr. Elektrochem. 7. pp. 501–505, March 14.

1901.)—When phenol is electrolysed in presence of normal hydrogen chloride it is not chlorinated, but oxidation takes place and the phenol thus acts as a depolariser and reduces the anode-potential from 1·8 to 0·862 volts. A similar effect is produced in presence of normal sulphuric acid. In presence of normal hydrogen iodide the phenol is unchanged, and the anode potential is the same (0·52 volts) as when no phenol is present. In presence of normal hydrogen bromide the phenol is oxidised and not brominated, but when the strength of the acid is increased fourfold a partial bromination results. The anode-potentials were measured against a normal hydrogen electrode throughout. T. M. L.

1158. *Electrolysis of Hydroxyacids.* **J. Hamonet.** (Comptes Rendus, 132. pp. 259–261, Feb. 11, 1901.)—The electrolysis of potassium β-amyloxy-propionate results in the formation of 1:4 diamyloxybutane. Of chemical interest only. N. L.

1159. *Aluminium as an Electrode.* **A. Bartorelli.** (N. Cimento, 1. pp. 112–133, Feb., 1901. Paper read at the annual meeting of the Italian Society of Physics, Sept., 1900.)—It has been long known that when an aluminium electrode is the anode in a voltameter the current passing is much weaker than when it is the kathode. History and references are given. There is some superficial change in the aluminium anode. The nature of this change is a subject of controversy. The resistance is very high, and the polarisation may attain very high values (17 volts, Streintz); but it is necessary to know these more definitely in terms of the current passing. A method is described for ascertaining the polarisation and the internal resistance concurrently during the passage of the current. If I be the current, E the p.d. at terminals, ϵ the counter e.m.f., and ρ the internal resistance of the voltameter, we have, where the aluminium electrode is the anode, and with current densities above 0·0025 and up to 0·1 ampere per sq. cm.,

$$E = I/(a + bI), \text{ where } a \text{ and } b \text{ are constants.}$$

The polarisation ϵ first neutralises the proper e.m.f. of the platinum-aluminium couple, and when it becomes $= 0$, the value of E/I is 155 ohms. The polarisation seems always to pass from negative to positive values at a current density of 0·0025 ampere per sq. cm. In long series of experiments while b is fairly constant, a seems to vary in such a way that $a/s = 0·0002$, where s is the area of the electrodes. We also find (the electrode being still the anode) that for current densities from 0·004 to 0·1 ampere per sq. cm.,

$$4\,a\,\rho = (1 + a\rho - b\epsilon)^2,$$
$$\epsilon = bE^2 = bI^2/(a+bI)^2,$$
$$\rho = a/(a+bI)^2 = (1-bE)^2/a.$$

The resistance of the voltameter diminishes, while the polarisation increases, as the current passing increases, the increase in the polarisation becoming progressively smaller. The polarisation is proportional to the square of the p.d. between the voltameter terminals, and it tends to become equal to it ($\epsilon = E$, and $b = 0·04$), and therefore tends towards a maximum, when $E = 25$ volts. The resistance similarly tends towards a minimum. In voltameters differing in section or in distance between the plates, the polarisation is the same when the current density is the same. The resistances of different voltameters are independent of the distances between the electrodes at given current densities, and are inversely proportional to their electrode surface. With the aluminium acting as kathode the polarisation gradually increases with the current density up to a maximum, after reaching which it is constant. The resistance at the same time gradually falls to a limit sensibly equal to the resistance of the electrolyte alone. The maximum polarisation when the aluminium is the kathode is notably less than that when it is the anode. For equal values of p.d. at the voltameter terminals the resistance is always less when the aluminium is the kathode than when it is the anode; and as the p.d. rises from very small values the ratio between the resistances in the two cases, at first very small, rises and approaches unity when the p.d. is about 25 volts. The summation of the effects of a gradually falling resistance and a counter e.m.f. gradually rising from negative values makes the current apparently undergo a considerable increase at a particular limiting value of the p.d.; but in reality there is no abrupt change. A. D.

1160. *Electrometallurgy of Copper.* **G. Codara.** (Elettricità, Milan, 20. pp. 20–21, Jan. 12; 39–41, Jan. 19; 56–57, Jan. 26; and pp. 67–70, Feb. 2, 1901).—The electrolytic separation of copper has one of two objects in view, either the separation of copper from its ores or its purification. Various processes for the latter purpose are now in commercial use, and are gradually taking the place of non-electrolytic methods. The electrolytic separation of copper from its ores, however, has not yet succeeded industrially. Four processes have been tried—Body's, Siemens and Halske's, Höpfner's, and Marchese's. The first process employs a horizontal carbon anode on which the ore lies, the kathodes being copper plates enclosed in felt; the electrolyte, of ferric sulphate and salt, is kept in circulation. In Siemens and Halske's process the ore is first roasted to reduce the copper to subsulphide; it is then treated with a solution of ferric sulphate with free sulphuric acid, whereby copper sulphate is formed, which is then electrolysed. This process has been worked on a large scale at Martinikenfel, at Pena de Herro and in the Tyrol without success. In Höpfner's process the carbon anode and copper kathode are separated by a diaphragm, and separate currents of a solution of protochloride of copper in brine are passed over each. The solution passing the kathode deposits its copper, that passing the anode retains it in the form of bichloride; the two solutions combined are passed over the ore, which changes the bichloride again into protochloride, with liberation of sulphur. The process was tried in the Saxony Erzgebirge, at Giessen and at Wiedenau without success. At Safenburg it gave good results with Rio Tinto 3·37 per cent. ore, the production being 54 kilos of copper per h.p. in twenty-four hours. In Marchese's process the low e.m.f. required to decompose the sulphide was taken advantage of by having anodes of copper sulphide cast in the form of plates. The electrolyte of copper sulphate was obtained by treating rich ore with dilute sulphuric acid. The process was tried at Casarza and at Stolberg without success, the low e.m.f. expected not being realised in practice. The last article is a description of the commercial process of purifying copper by electrolysis. The author treats of the various impurities which may occur in the copper, their behaviour during electrolysis, their effect in impoverishing the electrolyte, and their effect on the back e.m.f. He then describes the various processes and vats of Siemens and Halske, Borchers and Goslar, Stahlmann, Hayden, Smith, Randolf, and Thofehrn. Copper electrolysis has its greatest development in the United States, where there are twelve plants with a total capacity of 400 tons daily. G. H. B.

1161. *Mercury Cell for Electrolytic Soda and Chlorine.* **E. Franke.** (Amer. Electn. 13. p. 104, March, 1901.)—The author describes a new form of mercury cell in which the mercury is used as kathode in the form of a falling stream, with carbon or platinum anodes of larger superficial areas. The advantages claimed for this form of cell are:—(1) Low e.m.f. consequent upon rapid removal of the mercury amalgam from the cell. (2) High current efficiency. (3) Diminution of weight of mercury required to obtain a given yield of soda. (4) Increased yield per unit of plant, due to the use of cells containing a large number of alternate vertical anodes, and falling mercury kathodes. As regards the weight of mercury required, the author gives figures showing that using a warm concentrated salt solution with carbon anodes 3 cm. apart, a flow of 2 grammes of mercury per second sufficed for a current of 0·7 ampere when the e.m.f. was 4 volts. By substituting platinum for carbon, the current with the same e.m.f. was increased to 1·2 amperes. In an experiment upon a larger scale, 500 grammes mercury per second were required to carry a current of 160 amperes with an e.m.f. of 4 volts and carbon anodes. This weight was reduced to 100–150 grammes per second, for the same current, when platinum was used as anode material. Owing to the rapid passage of mercury through the cell the amalgam obtained from it is not rich in sodium. Cells of glazed stoneware, 31½ inches square, with alternate anodes and kathodes as described, can be used for currents of 3,000 amperes at 4 volts. An electrical current efficiency of 98 per cent. has been recorded with this form of cell. J. B. C. K.

1162. *Electrolytic Phosphorus.* (Elect. World and Engineer, 37. pp. 360–361, March 2, 1901.)—This article contains a brief illustrated description of the method of producing phosphorus, worked out by Dr. Machalske in his laboratory at Long Island City, New York. Ordinary phosphate rock is used as raw material. No details are given of any preliminary grinding or mixing, so presumably the rock is used in its natural state.

The furnace is constructed of red-brick and fire-clay. The sides are lined with calcined magnesia. The hearth is formed of a block of carbon, and forms one electrode, while a movable rod of carbon, 8 feet long and 4 inches in diameter, functions as the other. The actual furnace cavity is only 12 inches by 18 inches. Each furnace is provided with a hopper for charging the raw material, and with flues for carrying away the vapours of the phosphorus produced. These are condensed under water. The other product of the electrolysis is a slag which flows away as produced from outlets in the side of the furnace. No detailed figures for the yield of this furnace are given, but it is stated that using electric energy costing 3 cents per e.h.p.-hour, yellow phosphorus can be produced at a cost of only 7 cents per lb.

A company called the Anglo-American Chemical Company has been formed to exploit this process upon an industrial scale. J. B. C. K.

1163. *Electrolytic Hypochlorites.* **A. Brochet.** (Elektrochem. Zeitschr. 7. pp. 263–265, March, 1901.)—The author in this article describes the Hermite, Corbin, Kellner, and Haas and Oettel forms of cell for hypochlorite production, and gives figures for the yields of the cells.

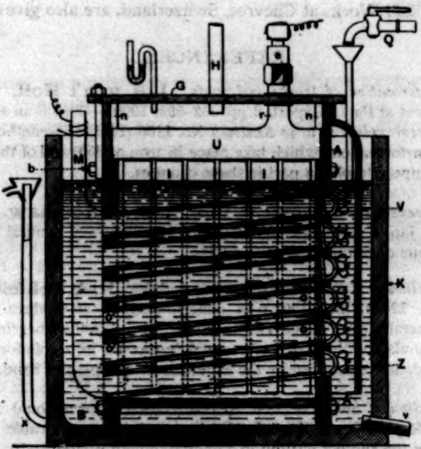
These are slightly different from those given in other articles upon this subject [see Abstract Nos. 1902 (1900) and 537 (1901)]. For the Hermite cell 1,000–1,200 amperes at 5–6 volts are stated to yield 40 kg. active chlorine per 24 hours. The yield for the Corbin cell is given as 50 kg. active chlorine per

24 hours with a current of 150 ampères at 120 volts. The Kellner type of cell with secondary electrodes of glass covered with platinum-foil (the glass and foil being perforated, and the foil kept in position by platinum wires passing through the perforations), yields 5·5 kg. active chlorine in 8 hours with a current of 114 ampères at 112 volts. For the Haas and Oettel cell, the figures given are 6 kg. active chlorine in 10 hours with a current of 40 amperes at 110 volts.

It is not stated whether these figures are based upon the author's own experiments or whether they are based upon trials made by the inventors of the various types of cell. J. B. C. K.

1164. *Outhenin-Chalandre Electrolytic Alkali Process.* **J. B. C. Kershaw.** (Electrician, 46. pp. 853–854, March 29, 1901.)—This process for the production of alkalies and chlorine compounds by the electrolysis of solutions of sodium or potassium chloride, is a diaphragm one, and is in actual operation at Chevres, near Geneva, and at Moutiers in France, while works are being built for the same process in Italy and Spain.

The figure is a sectional elevation of the cell, which consists of the outer and inner vessels, K and A. The inner vessel is filled with rows of porous-diaphragm tubes o o, in communication at one end with the chamber K, as shown. Each tube contains an iron kathode, which runs the whole length of its interior, while the anodes are round rods of carbon fixed into the lead head-piece U, from the surface of which the chlorine is carried away by the outlet pipe H.



The inner chamber A, is nearly filled with a concentrated solution of sodium chloride, and the outer with dilute sodium hydrate. The electrical connections are then made.

The chlorine gas evolved is employed for the manufacture of bleaching powder, and for the manufacture of pure chemicals for laboratory and medical purposes, while liquefied chlorine is also one of the products of the works. The sodium liberated at the kathode surfaces decomposes the water, with formation of caustic soda, which, owing to its high specific gravity, travels down the tubes, and collects on the bottom of the cell, and when required is run off by the outlet pipe V.

The hydrogen liberated at the kathodes is collected and burnt in a special form of burner in an atmosphere of chlorine, the resultant hydrochloric acid being fed into the anode chamber for the decomposition of hypochlorites. The excess of hydrochloric acid is split up by the electrolysis into its component parts, with production of chlorine at the anode and hydrogen at the kathode.

The advantages claimed for this class of cells are :—Complete separation of the electrolyte in the anodic and kathodic compartments, with consequent prevention of hypochlorite and chlorate formation. Collection and utilisation of the hydrogen evolved.

The author is rather doubtful about the advantages of this cell, and until figures have been published, showing the yield under actual working conditions, comparison of its efficiency with the Castner and Hargreaves-Bird cells is impossible.

Photographs of the power station of the Geneva Municipality and the Electrolytic Alkali Works at Chevres, Switzerland, are also given. O. J. S.

REFERENCES.

1165. *Transformation of Iron Compounds.* **J. H. van't Hoff.** (International Physical Congress at Paris, Report, 2. pp. 532–535, 1900.)—This is an appendix to the report on hysteresis referred to in Abstract No. 1136 (1901). The author gives an account of the transformations which take place in iron at 850° and of the carbon compounds which appear to play a part in these changes. P. E. S.

1166. *Electrochemical Industries in* 1900. **J. B. C. Kershaw.** (Electrician, 46. pp. 388–391, Jan. 4 ; and pp. 428–429, Jan. 11, 1901.)—A general review of the present conditions of commercial electrolysis.

1167. *Deposition of Metals from Mixed Electrolytes.* **R. A. Lehfeldt.** (Electro-Chemist, 1. pp. 12–13, Jan., 1901.)—A concise account of modern views on the deposition of metals from mixed electrolytes. The practical bearing of Nernst's logarithmic formula for the e.m.f. of a metal immersed in a solution of one of its salts is explained, and illustrated by the experiments of Ogg and Sand. N. L.

1168. *Ionisation of Solutions.* **S. Arrhenius.** (International Physical Congress at Paris, Report, 2. pp. 365–389, 1900.)—A brief but admirable historical and critical *résumé* of the subject written in a simple though precise style. J. E.-M.

1169. *Theory of the Voltaic Cell.* **L. Poincaré.** (International Physical Congress at Paris, Report, 2. pp. 403–421, 1900.)—This article gives a brief sketch of the gradual development of the theory of the voltaic cell. It is divided into three sections. Section I. deals with the application of the laws of thermodynamics without subsidiary hypotheses, and gives an account of the theoretical development of this portion of the subject in the hands of Helmholtz and Gibbs, together with a brief account of the experimental researches which have verified the theory. Section II. deals with the *mechanism* whereby the potential-differences are produced, and consists chiefly in a description of the Nernst-van't Hoff-Arrhenius theory. Section III. deals with the *seat* of the electromotive force. The author appears here to favour the view that in the case of an ordinary cell with different metals as electrodes, the p.d.'s at the metallic junctions play no inconsiderable part, and refers to the researches of Kelvin and Pellat in support of this view. F. G. D.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1170. *Steam Turbine.* (Engineering, 70. pp. 880–881, 1900. Electrician, 46. pp. 425–428, Jan. 11, 1901.)—Accounts of a test of a 1,000-kw. set of steam turbine and alternator, constructed by C. A. Parsons & Co., of Newcastle, for the Electricity Supply Works at Elberfeld. The following table gives a summary of the results:—

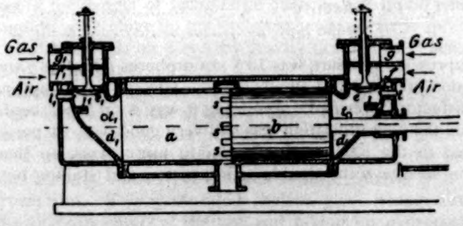
Load.	Output.	Steam per hr.	Steam per kw.-hr.
Overload	1,190·1 kw.	10,485 kg.	19·43 lbs.
Normal load	994·8	9,092	20·15
Three-quarter load	745·3	7,542	22·31
Half load	498·7	5,695	25·20
Quarter load	246·5	3,774	33·76
No load	0	1,183	—

These results are not directly comparable with one another, as they were not all made under the same conditions of steam-pressure and superheating. The steam pressure was about 10 atmospheres (absolute) and mean superheat 26° F.

H. R. C.

GAS AND OIL ENGINES.

1171. *Koerting 350-h.p. Gas Engine.* (Engineer, 91. pp. 23–24, Jan. 4, 1901.)—This two-cycle engine has one motor cylinder double-acting, like a steam engine, with a piston-rod and cross-head working through guides, and a crank. There is an admission lift valve, shown in the figure, at each end of the cylinder, driven from a cam shaft. The discharge of the burnt products is through ports, *s*, and through the annular passage around the middle of the cylinder uncovered by the piston. The length of the double-acting piston is equal to the stroke, less the width of the exhaust ports. The gas and air enter the admission valves by separate pipes from two double-acting pumps, both driven from an auxiliary crank 110° in advance of the motor crank. There is a projection in the cylinder below each admission valve, to prevent the heavy incoming gases streaming down to the exhaust ports, leaving the burnt products in the upper part of the cylinder. A scavenger charge of air is first



admitted between the products of combustion and the fresh explosive charge. To ensure prompt ignition there are two electric ignition ports at both ends of the cylinder at two different places in the compression space.

The usual cycle is carried out in two strokes instead of four. At light loads the gas-pump piston-valves, acted on by the governor, hold open the connection with the gas-pipe longer, and thus as the speed increases more gas is returned to the pipe and less passes to the cylinder.

The stuffing-box has metallic packing, and is carefully water-cooled. The cooling water for the piston and piston-rod is conveyed through tubes of the sliding telescopic type, moving to and fro with the cross-head.

The first 350-h.p. engine of this kind was tested by Meyer, at the works of Messrs. Koerting. The diameter of the motor cylinder was 21·6 inches, stroke 37·7 inches; diameter of the air-pump 24·4 inches, of the gas-pump 19·6 inches, and stroke of both pumps 27·5 inches.

The engine was driven by power-gas from a Koerting producer, and the work was absorbed by an electric brake which was not very reliable. The consumption was taken in a large gas-meter, and the (lower) heating value of the gas frequently measured by means of a Junkers calorimeter. The results in a trial run of an hour at full load were :—

Mean (metric) power indicated in the motor cylinder	544	h.p.
„ „ „ pumps	63	„
„ „ effective indicated	481	„
„ „ on the brake	341·5	„
Mechanical efficiency	71	per cent.
Mean number of revolutions per minute	101	
Heating value of the gas (lower) B.Th.U. per cubic foot	129	

Consumption of Gas per hour in cubic feet.

Consumption of gas per total i.h.p. (including pumps)	51
„ „ „ (excluding pumps)	58
„ „ brake h.p.	81·5

Thermal Efficiency of Engine.

Thermal efficiency per gross indicated h.p.	37·9	per cent.
„ „ effective „	33·5	„
„ „ brake h.p.	23·8	„

The compression pressure was 12·5 atmospheres (absolute), and the maximum explosion pressure 27·5 atmospheres. The gas consumption could not be quite satisfactorily verified. Assuming it was 4 or 5 per cent. above the figures given, the heat utilisation was still very good, viz., 24 per cent. of the heat supplied to the engine converted into useful work on the brake. It remains to be seen how the double-acting piston and stuffing-box wear.

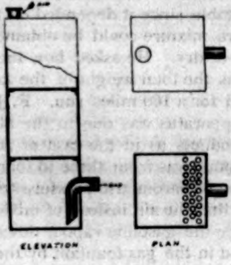
W. R.

1172. *Test of Gas Engines and Producers.* (Lightning, 18. pp. 594–595, 1900.)—The plant at Harmsworth's Works, Gravesend, consists of three Stockport T-size gas engines, each giving 80 b.h.p. at 200 r.p.m., and driving by belts Mavor and Coulson dynamos, at 560 r.p.m.; also two Dowson producers of 80 h.p. each. The two generators and two engines were worked alternately for a total period of 36 hours. The anthracite used was from the Gwaun-Cal-Gurwen colliery, costing £1 8s. 3d. on the wharf. The mean load was 41 kw., or 75 per cent. of the normal. The power was measured in electrical h.p.; the efficiency of the dynamos was taken as 90 per cent., and of the belt 95 per cent. The ignition tubes were supplied with town gas, the consumption being 15–20 cubic feet per engine per hour. The following figures give the results of the tests (by Handcock and Dykes), the consumption of fuel including stand-by losses in one generator for 36 hours.

Anthracite per kw.-hour	1·86 lbs.
„ b.h.p „	1·18 „
Coke per kw.-hour	0·305 „
„ b.h.p. „	0·193 „
Total fuel per kw.-hour	2·16 „
„ b.h.p. „	1·37 „

G. H. B.

1173. *New Gas Producer.* **J. A. Purves.** (Inst. Engin. and Shipbuilders, Trans. 44. pp. 18–23, Nov.; Discussion pp. 4–18, Dec., 1900.)—"Air-gas" consists of a mixture of air and vapour of petroleum or liquid hydrocarbon, such as gasoline, petroleum spirit, or pentane. The proportion of vapour which can be taken up varies with the temperature of air and the volatility of the petroleum. Air-carburetters may be divided into three classes:—(1) Air is *forced under pressure* through or over liquid petroleum; (2) on account of the danger of using large quantities of liquid petroleum, an absorbent is employed to take up the hydrocarbon, and air is forced over or through the absorbent; (3) air flows by gravity through the "aero-gas fountain" described in this paper.



In 1895, Naum Notkin, of Moscow, took advantage of the property that carburetted air is heavier than ordinary air. His automatic carburetter, called an "aero-gas fountain," consists of a tin vessel, shown in the Figure, with an orifice at the top and a bent "draw-off" pipe at the bottom, filled with a porous material (wood pulp) which is impregnated with one of the lighter hydrocarbons. Two perforated shelves give a long travel to, and distribute, the air. Air enters at the top, and taking up hydrocarbon vapour becomes heavier and gravitates through the mass of absorbent, taking up more and more of the vapour, until it issues from the lower orifice, and may be used for lighting, heating, and power purposes. The gaseous mixture becomes heavier and cooler by the rapid volatilisation of petroleum.

Argand burners with steatite centres and very wide gasways give with this "air-gas" a light of high illuminating power. No attention is necessary beyond the refilling of the carburetter when it becomes empty. Illustrations are given in the paper showing the application of this carburetter to table and street lamps, ships' lights; also to stoves and heaters. When the carburetter is exhausted of petrol, the tin box can be lifted out and a fresh one put in its place.

The yield of the aero-gas from a gallon of petroleum will give in an ordinary Argand burner from 700 to 1,000 c.p.-hours, depending upon the quality of the petroleum used. With petroleum at 1s. per gallon the cost of light is equivalent to that of 14-c.p. gas at 3s. 4d. per 1,000 cubic feet, giving 2·8 c.p.-hours per cubic foot. The gas can be used more economically in the Wenham and Siemens regenerative burners than in the Argand, and still greater efficiency is obtained with incandescent mantles. The aero-gas fountain can be used for gas engines, motor cars, and for launches.

Discussion.—**T. B. Murray** pointed out the only novel feature was that the apparatus worked by gravity, and hence did not require a fan to blow or force air through the gasoline. This property was of little or no value for motor cars or gas engines, since the suction caused by the forward stroke of the piston gave ample flow of air for carburation. Somewhat similar carburetters had been tried and abandoned for several reasons, such as the difficulty of obtaining a proper explosive mixture due to the varying temperature and humidity of the atmosphere; consequently in a car the mixing valves required continual adjusting by an expert to get good results. Again, the lighter hydrocarbons were evaporated first, leaving behind a residue, in some cases heavy and difficult of volatilisation with cold, damp air. A *spray* carburetter was more suitable, since it depended on mechanical action, and in practice a good explosive mixture could be obtained under all conditions—winter and summer, wet or dry. He asked how the petrol was fed into the carburetter, and what was the total weight of the latter containing the four gallons of petrol required for a 100 miles' run. **F. J. Rowan** said the convenience of the Notkin apparatus was due to the absence of all machinery. There were no waste products as in the case of acetylene and similar gas generators. Gasoline vapour was from three to four times the weight of air, so that any slight variation of barometric pressure could not affect the action very much. He thought that the air, instead of mixing with the vapour, acted more like a piston to force the gasoline vapour down the pipes, or, rather, to occupy the space left void in the gas fountain by the vapour falling. In the case of large buildings in France, a battery of gas fountains was placed near the roof, and the only precaution needed to insure constant supply was to put smaller pipes in the lower part of the building, because the pressure increased with the "head" of vapour, similarly to water. **N. D. Macdonald** had tested the apparatus on an autocar in which it was desirable to get rid of the difficulties and dangers of carrying liquid petrol. A regulator enabled the density of the gas to be delicately adjusted. J. Macdonald had driven from London to York, a distance of 200 miles, without any delay or accident, his motor car being fitted with a Notkin generator, which behaved beautifully in spite of a storm of hail, rain, and wind all the way. **A. Wilson** remarked that the oil used by Purves had a specific gravity of 0·65, cost 1s. per gallon, and gave 700 to 1,000 c.p.-hours; whereas the oil he (Wilson) used at Dawsholm gas works for enriching purposes had a specific gravity of 0·85, cost about half the price, and yielded over 1,500 c.p.-hours per gallon. The difference was due to the fact that the admixture of 1 per cent. of air with petroleum gas reduced the candle-power about 6 per cent. The atmospheric pressure would be the same on the top of the system as at the burners, and would not, he thought, affect the question at all. **R. Watson** considered the apparatus was open to a rather serious objection, viz., danger of fire or explosion, besides a disagreeable smell. The air was admitted through a regulator, and unless this was constructed to prevent the exit of carburetted air *by diffusion*, when the light was shut off and the downward current stopped, there would be at least the smell of the spirit used in carburetting the air. **Q. Galbraith** was of opinion that the pressure required to drive the gas through the pipes would be apt to vary with the state of the atmosphere. All the driving force available would be the difference in weight between the vaporised gas and the outside air—the one varied with the quality of the gasoline used, and the other with the weather. When both were against the gas there would be bad light, or none at all. He had had this trouble in twenty-five years' experience of machines in which air under pressure was forced through gasoline by means of weights and fans—positive mechanical appliances. **Purves,** in reply, said that in large installations at Lyons for the illumination of a hospital, barracks, church, and college, the gas fountains were stored in the upper part of the buildings in series battery form with a system of graduated piping, and worked satisfactorily. The weight of the vapour from petroleum, of specific gravity 0·68, being three to four times the weight of air, was amply sufficient to produce a flow and overcome the friction in the pipes with curved bends—sharp ones being avoided. With the most suitable petroleum, of 0·65 to 0·66 specific gravity, the weight of vapour was 2¾ times the weight of air. As to motor cars, the difficulties raised by Murray had been got over by a special carburetter and regulator. On the 6-h.p. Daimler motor it was usual to take one gallon of petrol for a run of 20 miles. On the run from London to York the petrol used amounted roughly to half a gallon per 20 miles. The residue was small, and the clogging up of the absorbent very trifling. The absorbent cost 5s. to 6s. per cwt., so that the cost of filling the box was a fraction of a penny. A gallon of the most suitable petroleum should weigh 6·5 lbs. A blue and inefficient light only could be obtained from paraffin; and one of the lighter and more volatile hydrocarbons must be used. He had tried, but failed, to induce a back draught so as to produce an explosion in the apparatus or set it on fire. The carburetters on motor cars were 2 feet in length by a foot square, and each held three gallons of petroleum. When one was exhausted, as indicated by the reduction in the power of the engine, another could be used. W. R.

1174. *Explosive Power of Acetylene.* **R. H. Fenn.** (Eng. News, **44.** pp. 366–367, 1900. Condensed from a graduating thesis presented at the Clarkson School of Technology, Potsdam, N.Y.)—Photographic views are given of the cylinder and apparatus for testing the pressure of explosive mixtures of gas and air, including a gauge reading to 100 lbs. per square inch for initial pressure, an induction coil and sparking device to explode the mixtures, and a Crosby indicator using a 300-lb. spring with barrel belted to a revolving shaft giving a card with a continuous line for the rise and drop of pressure. A small generator produced the acetylene, each charge of which was measured over water in a calibrated bottle.

Experiments were made at initial atmospheric pressure with mixtures ranging from 15 parts by volume of air to 1 part of acetylene, to 8 parts air to 1 part acetylene. The 8 : 1 mixture showed very markedly the poor combustion due to lack of air, a heavy black soot being driven out of the cylinder on exhausting. A mixture of air to gas in the ratio of 9 : 1 gave the greatest explosive pressure, 112 lbs. per square inch. This was increased to 350 lbs. when the initial pressure before ignition was increased to 35 lbs. per square inch.

For comparison, a series of tests were made with mixtures of air and vaporised gasoline in the ratio 4 : 1, which gave the greatest explosive pressure, 165 lbs., at initial pressure of 20 lbs. At the same initial pressure the 9 : 1 mixture of air and acetylene produced a pressure $\frac{273}{165}$ greater than that by the gasoline, so that the volume of acetylene to give the same pressure need only be $\frac{1}{2} \times \frac{165}{273} = 0{\cdot}304$ of the gasoline.

Taking the theoretical indicator diagrams for the explosion of these two mixtures, the area of the acetylene diagram measured 4·91 square inches, and that of gasoline 1·79 square inches, giving a ratio of power nearly 3 : 1. Indicator diagrams show that the time-rate of the acetylene explosion is five times faster than that of the mixture of gasoline and air. A large quantity of heat is absorbed by the iron walls about the gas, thus reducing the maximum pressure, which is a function of the heat evolved by the explosion. As vaporised gasoline acts more slowly than acetylene, the practical test makes acetylene (mixture 9 : 1) 3·28 times more powerful than gasoline (ratio of 4 : 1), whereas theoretically it should be only three times as great.

The calorific value of the acetylene used was 1,350 thermal units and that of gasoline 700 heat units per cubic foot. A cubic foot of each of the above mixtures at initial atmospheric pressure would give 90 lbs. and 43 lbs. per square inch respectively. Allowed to expand adiabatically to 10 cubic feet, the calculated external work,—

$$W = \frac{p_1 v_1}{K-1}\left\{1 - \left(\frac{v_1}{v_2}\right)^{K-1}\right\}, \text{ (where } K = 1{\cdot}405\text{)},$$

would be for acetylene 22,403 foot lbs., and for gasoline 12,132 foot lbs. But only 0·0625 cubic feet of acetylene was used, while 0·20 cubic feet of gasoline was needed, or 3·2 times as much. With the given ratios of mixtures only 0·0312 cubic feet of acetylene is required to do the same work that 0·20 cubic feet of vaporised gasoline will do. Or comparing equal quantities of the two gases, acetylene has about 6·5 times the intrinsic energy of vaporised gasoline at the given ratios of air and gas.

Assuming an engine of total efficiency from fuel to useful work of 15 per cent., and a consumption of 22 cubic feet of gasoline gas per h.p. per hour, the cost of 1 h.p.-hour would be 0·65d. (1·3 cents), at 2s. 5d. (58 cents) per 1,000 cubic feet of vaporised gasoline. The cost per h.p. per hour for acetylene in an engine of equal efficiency would be 1·3d. (2·6 cents), with acetylene 33s. 4d. (8 dollars) per 1,000 cubic feet. To do the same work with acetylene in place of vaporised gasoline, therefore, would be about twice as expensive. For this reason acetylene would only be of practical use to produce power where light compact engines were required, as in automobiles. In the event of a 50 per cent. reduction in the price of calcium carbide, however, it might probably come into more general use for gas engines. W. R.

AUTOMOBILISM.[1]

1175. *Cooling of Explosion Motors.* (Horseless Age, 6. pp. 17–19, 1900. Extracts from the report of **Grouvelle** and **Arquembourg** at the International Congress of Automobilism of 1900.)—The report describes the methods at present in use for keeping the temperature of the cylinder walls of explosion motors within the limit at which the lubricating oil commences to decompose, viz., from 350° to 400° C. For cylinders developing up to 3 b.h.p. deep ribs, either cast with or suitably attached to the body and head, enable a sufficient surface to be exposed to the air to carry off the heat by radiation alone. For higher powers it is necessary to carry off the heat by means of water circulated in the cylinder jacket either by thermo-syphon action between the hot water in the jacket and the cooler water in a tank placed at a higher level than the cylinder; or by circulating the water by means of some form of pump. This pump is usually of the simplest possible centrifugal type driven by friction from the periphery of the engine fly-wheel. The authors mention two pumps of their own manufacture for which the capacities are as follows: (1) Diameter of fan 2 inches, speed 2,500 to 3,000 r.p.m., volume delivered 9·75 gallons per minute, for motors up to 6 b.h.p. (2) Diameter of fan 3¼ inches, speed 2,000 to 2,500 r.p.m., volume delivered 13·75 gallons per minute at a maximum pressure of 30 feet of water, for motors from 6 to 20 b.h.p. For this pump the supply pipe is ¾-inch bore, and delivery ⅝-inch bore. In the return water circuit between the engine and the water tank it is customary to employ a radiator or cooler mounted in an exposed position on the car and presenting as large a surface as possible to the air, for the purpose of dissipating the heat abstracted from the engine cylinders, and preventing the temperature of the water in the supply tank from reaching boiling-point. The radiator is usually composed of copper piping, to which thin radiating ribs of aluminium or iron are attached. The authors mention three sizes with pipes ½-inch, ⅝-inch, and ¾-inch bore respectively, having radiating surfaces of 0·84, 0·80, and 0·89 square feet per foot length. The radiating surface required per b.h.p. is not stated. C. R. D'E.

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[1] Electric Automobiles are described in the Section dealing with Electric Traction.

1176. *Turrell Gasolene Carriage.* (Horseless Age, 7. pp. 21–24, Jan. 16, 1901. From the Autocar.)—A description of a two-seated carriage propelled by a 7-h.p. two-cylinder horizontal engine mounted at the front of a channel steel underframe designed with a view to securing some flexibility between its front and back members. The power is transmitted from the engine shaft by means of a long belt to the change-speed gear, which consists of spur pinions gearing with spur wheels mounted loose on the exterior of the differential gear box sleeve on the live rear axle. By means of a special system of keying, any one of the spur wheels may be caused to drive the differential sleeve, and in this manner three forward and one reverse speeds may be obtained. Side elevation, plan, and end elevation of the engine show the disposition of the cylinders, crank-shaft and connecting rods, adopted to secure accurate balance and compactness. The sliding key system of the change speed gear is also clearly shown. C. R. D'E.

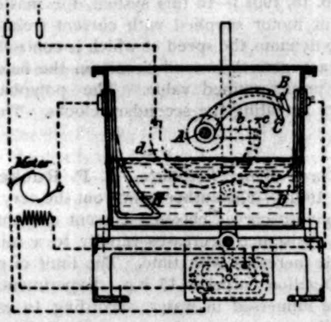
1177. *Automatic Tension Belt Transmission for Automobiles.* (Horseless Age, 7. pp. 23–25, Jan. 30, 1901. From the Zeitschr. Automobilen-Industrie und Motorenbau.)—This article describes a form of belt transmission in which the belt tension is automatically adjusted in proportion to the work to be done. In the arrangement of mechanism illustrated, the motor is placed at the front of a rectangular underframe with the crank-shaft in the direction of the length of the frame. The power is transmitted through a friction clutch to a change speed gear which drives a transverse shaft, having at its end belt pulleys from which are driven short independent shafts carrying spur pinions gearing with spur-wheel rings on the driving road wheels of the car. These short shafts are so mounted that they may turn about the rear axle without disengaging the final spur drives. To give a normal tension to the belt, helical springs are suitably arranged to pull the spur pinion shafts away from the change gear cross shaft. When the engine power is applied, the tendency of the spur pinions to rotate round the spur wheel rings in the opposite direction to the rotation of the road wheels exerts an automatic tension on the belts varying in proportion to the power transmitted. This arrangement also obviates the use of a special differential gear. C. R. D'E.

1178. *Rubber Tyres.* **M. Michelin.** (Horseless Age, 7. pp. 21–26, Jan. 2, 1901. Paper read before the International Automobile Congress.)—There are four classes of tyres: (1) Solid tyres put on the rims by force, (2) cemented, (3) wired, and (4) fastened by bolts. Pneumatic tyres deal with obstacles up to 1¼ inches; springs up to 4 inches. On motor cars pneumatics are chiefly valuable in preserving the life of the machinery. A steel wheel rolling on steel ground would have its speed increased if provided with a pneumatic tyre. But the author deprecates making any formulæ about roads, and relies entirely upon trials. He has found a solid rubber tyre better than iron on wood or snow-covered ground, but inferior when the road is hard and smooth. An electric cab was run 2 km. on solids at an average speed of 13·94 feet per second, and the energy taken was 1,087,680 watt seconds. The same cab, with four pneumatics, made the same distance in the same day with 817,840 watt seconds (diameter of wheels not given). Another experiment was made with 17·9 per cent. energy economy, and 5·3 per cent. gain in speed. The starting pull on a dead level was found to be 14 per cent. lower with pneumatics, the trial being effected by weights added to a pan connected to the car through a pulley. Mauny states that in transporting 1 ton of useful load a wear of 4 grammes of iron per kilometre was lost. The wear of a pneumatic tyre depends on small factors, for example, on steering-wheels; the play of a bad steering-gear increases the wear appreciably, as does also the slip of the tyres when the brakes are applied. The effect of dishing the wheels on the wear is remarked upon. The dishing of the front and rear wheels on the Darracq is 6 per cent. and 3 per cent. respectively, Peugot 2 per cent. and 4·7 per cent., Dietrich 3 per cent. and 6 per cent., and on the Panhard 4 per cent. Armoured tyres and self-healing tyres do not seem to be practicable. M. O'G.

GENERAL ELECTRICAL ENGINEERING.

1179. *Accumulator Acid.* **R. Heinz.** (Centralblatt für Accumulatoren, 2. pp. 35–36, Feb. 1, 1901.)—Sulphuric acid for storage cells must be very pure. It should be quite free from the metals that are precipitated by sulphuretted hydrogen, especially lead. The amount of iron should not exceed 0·01 per cent., nor that of chlorine 0·002 per cent., and of nitrogen, in whatever combination, the quantity should not be greater than 0·1 per cent. It should not have any organic impurities, and should be free from sulphuretted hydrogen. The author has had a long experience of the manufacture of sulphuric acid, and especially of acids used in accumulators, and finds that much impure acid is in use. Brimstone acid is usually free from arsenic, but sometimes traces are found. Acid made from sulphur obtained as a bye-product from sulphuretted hydrogen can be depended upon as arsenic free. Such acids when concentrated in the usual platinum or platinum-gold apparatus are as a rule very pure, and contain only traces of metallic impurities, and when diluted with *pure* water are very suitable for accumulator use. W. W. H. G.

1180. *Motor Starting-Switch.* **F. R. Dietze.** (Elektrotechn. Zeitschr. 22. 154–155, Feb. 14, 1901.)—This switch, which is combined with a resistance, is made by Flohr of Berlin, and is intended to give a very steady increase of current on starting the motor. It is mainly used in connection with lifts and cranes. The action of the switch can be understood from the accompanying drawing, which also shows the connections. At the bottom of the diagram is shown the commutating switch, which changes the direction of the current through the magnet coils. As soon as this switch is closed, the starting resistance is operated automatically; though in some forms of the switch the starting resistance is varied by hand. The resistance material is graphite, which is contained in a box, shown at the top of the drawing, and the revolution of the shovel-shaped pieces, B and C, closes respectively the circuits of the armature and magnet coils. The piece C comes eventually in contact with D, and the coils then receive the full working pressure; the



armature similarly receives the full voltage when B comes in contact with E. It is claimed that by this device the sparking and racking are much diminished, in consequence of the fact that the increase and decrease of the current is very steady, and that at the moment of breaking circuit no sparking occurs, seeing that the current is then extremely small. W. H. S.

1181. *Tests of Magnetic Circuit-Breakers.* **H. A. Brown.** (Elect. World and Engineer, 37. pp. 229–230, Feb. 9, 1901.)—Tests made to determine the time required for circuit-breakers to operate, and the maximum value of the current attained, show that current × (time — K) = a constant. The value of K varied from 0·005 to 0·023 with different circuit-breakers, and the time, with 100 per cent. more than the normal maximum load, from 0·042 to 0·078 seconds. A. H. A.

1182. *Brake Electromagnets for Electric Cranes.* **M. Vogelsang.** (Elektrotechn. Zeitschr. 22. pp. 175–177, Feb. 21, 1901.)—An illustrated description of a shunt-wound, iron-clad, brake-releasing magnet, provided with an automatic switch by means of which the resistance in series with the magnet-winding is short-circuited when the magnet is not excited. Hence, on closing the circuit, a very large current passes through the magnet coil, enabling it to exert a strong pull on the plunger, in spite of the long air-gap. The plunger, in rising, opens the short-circuiting switch, introducing the resistance into the short circuit, and reducing the exciting current to a safe limit for continuous working. A. H.

1183. *Thury Electric Time-distribution System.* **J. Reyval.** (Écl. Électr. 26. pp. 245–250, Feb. 16, 1901.)—In this system, the master-clock consists of a continuous-current motor supplied with current from accumulators and driving a polyphase dynamo, the speed of which is controlled by a centrifugal governor breaking a negatively wound circuit on the field magnet when the speed exceeds a predetermined value. The polyphase dynamo drives synchronous motors actuating the secondary clocks. The original paper is illustrated. C. K. F.

1184. *Immersed and Water Rheostats.* **B. P. Rucker.** (Amer. Electn. 13. pp. 72–74, Feb., 1901.)—The author points out the very variable resistance of water rheostats, giving curves between current and time for solutions of various salts. The resistance decreases rapidly to a minimum at boiling-point, after which it increases with time. The limit of power continuously absorbed with a 40-gallon barrel is 15 h.p. Experiments were made with spirals of iron wire immersed in water, according to which 100 h.p. was easily dissipated in the same space; there were nine coils of No. 12 galvanised iron wire, each having a resistance of 0·737 ohm when hot, and a stream of water was kept flowing. Other experiments are described, having for their object the prevention of electrolytic corrosion. In order to obtain fine adjustments, a plate rheostat may be used in series with the coil rheostat. A table of suitable sizes and lengths of wire for various currents is given (at 110 volts), from which it appears that the safe capacity in water is about 14 times the capacity in air. A. H. A.

1185. *Electric Drawbridge.* **H. G. Tyrrell.** (Elect. World and Engineer, 37. pp. 265–266, Feb. 16, 1901.)—Description of a new bridge across the Connecticut River at Middletown. Roadway 26 feet wide traversed by electric railway. Bridge 1,300 feet long, consisting of two spans of 200 feet, two of 225 feet, and the draw span of 450 feet. The drawbridge is operated by three 25-h.p. electric motors. H. R. C.

1186. *Electric Driving of Printing Machinery.* (Engineer, 90. pp. 41–43, 1900.)—The saving in space, cleanliness, and ease of stopping are the important advantages. Stopping is effected by a number of bell pushes which short-circuit an electromagnet on each starter. Sixteen or twenty newspapers are being worked electrically. Holmes uses two motors to each rotary web press; one may be 25 h.p. and the other 3 h.p. The machine shaft has a cast-iron toothed wheel driven by a brass pinion on the shaft of the large motor, which is prolonged on the side away from the press and carries one half of a crown wheel clutch. The clutch is worked magnetically, and the other half of it, which is of gunmetal, is carried on a shaft to which is keyed a worm wheel driven by a worm from the smaller motor. Through this worm the small motor effects the small speeds and slow movements of the press. The printing cylinder can thereby be moved through small angles without difficulty. The switch involves a large number of contacts, over which passes a sliding contact-piece moved by means of a worm and wheel. When the top speed is to be gained, the big motor takes up the load, by its speed gaining on that of the auxiliary motor, and pushes out the self-releasing clutch, the backward movement of which cuts out the small motor electrically and mechanically. The number of copies per hour turned out with 200 volts and 104 amperes is 48,000.

The Republic Newspaper of St. Louis takes current from the public supply, because the load-curves show that the bulk of the load occurs between 5 a.m. and 5 p.m., with a peak at 2 p.m., this being a desirable load for the power station. Three Hoe quadruple presses are driven by a motor running at 700 r.p.m., arranged by gear wheels to be below the floor; the slow speeds are obtained by a small motor-driven dynamo which delivers a potential varying between zero and 80 volts to the main motor. Each press has a 40-h.p. motor to allow for extensions to the press, which at present takes 30 h.p.

Each of the 20 Mergenthaler Linotypes is driven by a ¼-h.p. motor with worm gear. Powerful arc lamps are used in the art department for photographic work. The stereotype machine is driven by a 2½-h.p. compound-wound motor at 450 revs. The trimming saw is driven by a 4-h.p. motor at 1,400 revs. The shaper, which is used for shaping the curved interior surface of the stereotyped plates, takes 4 h.p. The pneumatic-tube delivery system is supplied from a blower driven by a 4-h.p. shunt motor.

The Cutler-Hammer press-drive employs but one motor. A simplified diagram is given of the connections as well as a working diagram, the shunt being automatically controlled by means of solenoids. If a sudden load is thrown on the motor, the solenoids act and open the circuit shunting the armature, thus preventing it from stopping. If the motor load falls off too rapidly for control by the central dash-pot solenoids, other solenoids come into play and short-circuit some of the shunting resistances. At top speeds the solenoids are thrown out of gear. This method is complicated, but is said to work well. [See further Abstract No. 1747 (1900).]

The electric installation of Alabaster, Pasmore & Sons, of Whitecross Street, London, is briefly described, two 35-h.p. gas engines being the motive power. Six lithograph presses are driven separately by either 2- or 3-h.p. motors according to size. The noise is said to be negligible. M. O'G.

1187. *Insulating Power of Snow.* **B. Brunhes.** (Comptes Rendus, 132. pp. 465–466, Feb. 25, 1901.)—Lespieau and Caurs on Mt. Blanc and Ricco on Mt. Etna have already shown that snow seems to be an insulator, since bare wires placed on the snow continue to transmit telegraphic and telephonic messages. The author describes two distinct tests on the same point which he made on the line to the summit of the Puy de Dôme.

(1) When a line is broken by wind, it is not necessary to raise and insulate it from the snow; the author merely attaches temporarily a wire to each broken end and leaves the intervening bare wire on the snow.

(2) In the severest winter weather the posts and their insulating cups and the wires are surrounded by a solid sheath of hoar-frost as much as ½ m. in diameter. Thus the wire is joined to the ground *by snow*, yet the insulation remains perfect. P. E. S.

1188. *Polyphase Currents.* **A. Potier.** (International Physical Congress at Paris, Report, 3. pp. 197–263, 1900.)—This report describes the main applications of polyphase currents to actual work, and contains many valuable and useful discussions of practical problems, generally from the point of view of the physicist. In transmitting power by polyphase currents to a given distance, the author proves that if R be the resistance in parallel of all the copper mains used, W the power generated, and V the potential difference between each main and earth, then, whatever the number of phases, the ratio of the power lost in the main to the total power—

$$=\frac{RW}{V^2\cos^2\phi},$$

where $\cos\phi$ is the power factor of each main. Hence, whatever the number of phases, the loss for the same power-transmission is the same if the p.d. beween each main and earth is the same. When we keep the p.d. between consecutive mains the same, then this is not true. In this case the weight of copper in the three-phase is to its weight in the single phase, as 75 is to 100. If we admit that the difficulties of insulating cables depend on the p.d. between the mains, then this would explain why the three-phase currents are nearly invariably employed for long-distance transmission. If E be the p.d. between adjacent wires, then for direct current the percentage loss is $\frac{4RW}{E^2}$ and for three phase $\frac{3RW}{E^2\cos^2\phi}$. Remembering that in practice $\cos\phi$ generally lies between 0·7 and 0·8, it will be seen that the advantage is in favour of continuous current.

An excellent description is given of how the magnetic field glides round the air-gap between the rotor and the stator of an induction motor. It is proved that if the currents follow the harmonic law, and if the radial magnetic forces at points round the circumference of the rotor due to constant currents in any of the windings also follow a harmonic law, then the magnetic field is sinusoidal, and glides round the air-gap with uniform angular velocity. Great stress is laid on the importance of the artifice of substituting fields rotating in opposite directions for fixed oscillating fields, and the properties of these rotating fields are fully considered.

A fairly complete theory of the working of asynchronous motors is given. The author states that the leakage factor (σ) is about 0·1 in good machines. The action and parallel working of polyphase alternators is discussed. The following method is given of telling the relative speeds of two three-phasers when being synchronised. A small three-phase transformer is connected across the terminals of each machine. Let 1, 2, and 3 be the three secondary circuits of the first transformer, and let each of them be put in series with the corresponding circuit of the second transformer through a lamp. If the incoming alternator is running slower than the other, then the lamps attain their maximum brilliancy in the order 1, 2, 3; if it is running quicker than the other, then the rotation takes place in the reverse order 3, 2, 1. [See Abstract No. 892 (1899).]

Proofs of the methods of converting from one polyphase system to another by transformers are given. Formulæ are also found for rotary converters and permutators. The author concludes by describing Leblanc's system of using asynchronous machines as generators [see Abstracts No. 746 (1900), and No. 576 (1901).] If we have several machines of this type, it is sufficient that their polyphase windings receive currents from the same source in order to ensure that the induced electromotive forces should all have absolutely the same period. Hence the paralleling of such machines could be done as easily as that of direct-current dynamos. The machine which supplies the polyphase currents and thus sets the time to the other machines may be quite small. The author compares its *rôle* to that of a *chef d'orchestre*. A. R.

REFERENCES.

1189. *Lightning Conductors.* **F. Findeisen.** (Elektrotechn. Zeitschr. 22. pp. 139–145, Feb. 7, 1901.)—This paper is a detailed reply to the discussion on the author's publication, "Hints on Protection from Lightning," at the meeting of the Elektrotechnische Verein, held on May 22, 1900. [Abstract No. 2099 (1900).] The publication contained the results of the investigations carried out by a committee appointed by the Society. G. H. B.

1190. *Standardisation of Edison Screw Sockets.* **R. Hundhausen.** (Elektrotechn. Zeitschr. 21. pp. 921–924, 1900.)—Report of the German Commission on the subject.

1191. *Steam Heating from Central Stations.* **W. H. Bryan.** (Eng. News, 45. pp. 109–112, Feb. 7, 1901. Abstract of a paper read before the American Soc. of Heating and Ventilating Engineers, N.Y., Jan. 22–24, 1901.)—The suggested arrangement is that a central electricity station should also supply heat by means of steampipes, using the exhaust steam from the engines and, when this is not sufficient, live steam in addition. [The economy of the engines seems throughout to be considered of quite minor importance.] H. R. C.

1192. *Electrical Machinery in Coal Mining.* **W. C. Mountain.** (Elect. Rev. 48. pp. 239–243, Feb. 8, 1901.)—This is a short paper dealing generally with the application of electrical power in coal mining, showing the plant used, the capital outlay and saving achieved in actual cases in British practice. Various types of reciprocating and rotary pumps, haulage engines, and coal cutting machines, are described. The paper is illustrated with admirable reproductions from actual photos. Ll. B. A.

GENERATORS, MOTORS, AND TRANSFORMERS.

1193. *Rating of Tramway Motors.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 134–137. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 92–94 and 201–206.)—**C. H. Macloskie**, the author of the report, proposes as a definition of the power of a motor, the power supplied in kilowatts when the motor is working on a load such that its temperature after one hour will be 75° C. above that of the surrounding air. As an indication of the speed, he proposes a constant depending on the current, and the tractive effort on the rim of the wheels. The curve of a tramway motor between current and effort is practically a straight line, if only the working portion be considered, and may be represented by—

$$x = ny - m, \text{ or } y = \frac{x}{n} + \frac{m}{n}$$

where y is the current, x the tractive effort in kilos, and m and n are constants.

The author writes $y = A\frac{x}{1000} + B$, and proposes to complete the rating of a motor by the constants A and B. B would represent the idle current of the motor if the curve were a straight line throughout, and gives some indication of the losses. A represents, in milliamperes, the current required per kilo of tractive effort at the wheel-rims, and determines the speed of the motor for a given wheel diameter, which the author takes as 800 mm. The speed in kilometres per hour is given by—

$$146\left\{\frac{A}{1000}\cdot\frac{d}{800} + \frac{B}{x}\right\},$$

assuming an efficiency of 80 per cent., d being the wheel diameter in mm. Knowing A and B, the current required to give any tractive effort can be found from the first formula. The author then proposes to rate a motor by three figures, the first being the power in kw., as defined above; the second, A; and the third, B. On this system, for example, the Thomson-Houston motor G.E.-51-B-6 would be rated by 70-162-29, and the motor G.E.-62 by 26-91-18. The weight of a motor is approximately $5000\frac{B}{A}$.

Discussion.—**D'Hoop** considered that the conditions under which the power of the motor is determined should be more precise. **Hospitalier** proposed a different system of rating; as the speed increases, the power of the motor passes a maximum value; this maximum should be taken as the normal power of the motor, which is further defined by the following factors: the maximum couple at starting, the speed and the couple corresponding to the maximum power, and the speed at which the couple vanishes.

G. H. B.

1194. *Measurement of Slip in Induction Motors.* **G. Seibt.** (Elektrotechn. Zeitschr. 22. p. 194, Feb. 28, 1901.)—The difficulties connected with the accurate determination of the slip from the speeds of the generator and motor are sufficiently well known. An accurate measurement is only possible with a method which measures the slip directly, and not as the difference of two quantities, each of which is large in comparison with the slip. The author suggests the following method, which is applicable to short-circuited as well as to wound motors. A Joubert contact-disc provided with a contact-piece of suitable width is fixed to the shaft of the rotor. In series with this is joined an incandescent lamp, the entire circuit being connected across two of the supply mains. The lamp will light up or grow dim according as the interval of contact happens to be in the neighbourhood of the maximum or the zero value of the p.d.-wave. The frequency of the light fluctuations determines the slip if the speed of the motor is known. Instead of the lamp, a voltmeter, or—better still—a Morse instrument may be used. The method has been tried by the author with very satisfactory results. A. H.

1195. *Rotary Converters.* **W. E. Goldsborough.** (West. Electn. 28. p. 86, Feb. 2; Discussion, pp. 102–103, Feb. 9, 1901. Paper read before the North-Western Electrical Association at Milwaukee, Wis., Jan. 17, 1901.)—A simple non-mathematical explanation from first principles is given of the theory of rotary converters. The author points out the apparent paradox that a large part of the alternating current never enters the machine at all, as twice in every oscillation of the alternating current the direct current entirely neutralises the alternating current in the windings of the armature. Outside the armature windings, however, the direct and alternating currents at these times are flowing in the same direction. Steinmetz's table [Abstract No. 758 (1899)], giving the comparative capacity ratio of different types of synchronous converters, is quoted. Stress is laid on the fact that a synchronous converter acts like a condenser on a choking coil according as the field magnets are over- or under-excited. This fact is made use of to improve the power factor of the station load. The field excitation should be so adjusted at light loads as to promote lagging currents in the system, *i.e.*, the converter fields should be under-excited. With this adjustment, as the load comes on, the series winding by strengthening the field will improve the power factor until it is 100 per cent. at full load. A frequency of sixty is the upper limit of the frequency for practical working. The best results are obtained with frequencies between 25 and 40. The inductance of the armature should be high. This means that the coils are placed in deep slots, and that teeth with projecting heads are not objectionable. If the inductances are low the machines are liable to hunt. In starting synchronous converters from the alternating current side, the exciting circuit should be opened, and it is advisable to disconnect the field windings from each other, as the excessive voltage sometimes induced in them breaks down the insulation. Boosting transformers are often used at starting so as to prevent large starting currents causing voltage fluctuations in the distributing system. When a converter is started from the alternating current mains, an alternating e.m.f. is apparent at the commutator brushes, the frequency of which diminishes as the speed increases. Lamps connected across the brushes show by their pulsating light the degree of synchronism attained. When synchronism is attained the load is put on the converter.

Discussion.—**H. J. Gille** asked if the figures given in Steinmetz's table were true at all loads. He also said that he had found trouble with rotary converters, as they often caused the mains to become unaccountably hot. **D. C. Jackson** said that it was a practical impossibility to get unity power factor with a rotary converter or any other synchronous type of machine run under ordinary conditions. In the first place there was always a slight amount of "hunting" or wobbling of the armature, and in the second place the shape of the p.d. wave was never an exact copy of the shape of the current wave.

In his reply the author stated that Steinmetz's table was only true for sine-curve waves and for light loads. He suggested two explanations of the heating of the mains mentioned by Gille. The first, that it was simply a Kelvin effect, the current repelled to the circumference of the cable making the current density near the circumference too great. The second explanation was that it was caused by difference of wave form between the alternator and the converter e.m.f.'s, so that idle currents flowed between the two machines simply to fill in the gaps in the wave forms. A. R.

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1196. *Electrical Machinery at the Paris Exhibition.* (Electrician, 45. pp. 470–473; 507–510; 550–554; 663–666; 694–697; 768–772; 844–848; and 886–888, 1900.)—Articles describing the most important machines exhibited, and containing several drawings showing details and general arrangements.

1197. *Short-Circuited Rotors of Induction Motors.* **M. Osnos.** (Elektrotechn. Zeitschr. 22. pp. 172–175, Feb. 21, 1901.)—The author deals with the effect of the end-rings in increasing the resistance of the rotor bars, and compares the relative amounts of copper required for end-connections, for the same increase of resistance, in the case of a short-circuited and a wound rotor. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1198. *Cost of Power.* **J. B. C. Kershaw.** (Elect. Rev. 47. pp. 496–499, and 563–564; Discussion, p. 564, 1900. Paper read before the British Association.)—The author has collected a variety of statistics bearing on the cost of power in different parts of the world. Dealing first with steam power, the figures vary from £3 12s. 10d. per i.h.p.-year of 8,760 hours to £26 5s. 1d. The former figure is given by Dawson as being the cost in large tramway stations, while the latter figure refers to Siemens' Woolwich works. Siemens' figure is, however, very much higher than any other figure quoted, the ordinary price in England and America appearing to be in the neighbourhood of £6. Raworth estimates the cost with superheated steam and modern engines and boilers, used on a large scale, to be £3 14s., and this figure has been verified in certain cotton mills where coal is cheap. Much obviously depends on the cost of coal, and comparisons are not always possible. Coming next to water-power, the figures are given per e.h.p.-year. They vary from £1 in Norway to £26 11s., which is the charge to small consumers in Buffalo. Here again comparisons are difficult, inasmuch as in some cases the actual operating costs only are given, and in other cases the charges to consumers. With regard to gas-power, estimates only are given. Meyer estimates that power produced by blast furnace gases would cost £4 1s. 7d., and with Mond producer gas Humphreys puts the figure at £5. Comparing these figures in so far as any comparison is possible, it would appear that under favourable conditions water-power is much the cheapest. But generally the conditions are not favourable, and immense expense has to be incurred either in hydraulic engineering or in transmitting the power generated over a considerable distance, or in both. The author states that power from water is costing more in Rheinfelden, at Zurich, and at Buffalo than it would do if generated by steam in Lancashire. The paper contains much useful information, and the authorities for the various figures are in all cases given.

W. H. S.

1199. *Determination of the Price of Electric Energy Supplied from Central Stations.* **K. Wilkens.** (Elektrotechn. Zeitschr. 22. pp. 116–118, Feb. 7, 1901.)—After giving curves and diagrams illustrating the variation of the load during the 24 hours and throughout the year, the author deduces the following equation for the prime cost k of unit energy for the separate consumers:—

$$k = \frac{Cm}{A} + s,$$

where $A =$ the amount of current taken in a year by a given consumer; $C = Z/M$, where $M =$ the sum of the currents taken by the whole of the consumers at the time of maximum load at the central station, and $m =$ the current taken by the given consumer at this time; $Z =$ the total expenses for interest and depreciation; and $s =$ cost of generating one unit of current. This equation is then applied to different classes of consumers with the figures obtained from 26 continental stations, which are given in a table. The mean values so obtained are as follows:—$C = 35{,}600$, since for each kw.

supplied to the consumer at the time of maximum load, 3,560 m. capital must be expended, taking 74 per cent. as the ratio of the useful energy to the total energy generated; $s = 13{\cdot}53$ pfennig. Thus where $m = 140$ kw. and $A = 115{,}000$ kw.-hours, $k = \frac{35{,}600 \times 140}{115{,}000} + 13{\cdot}53 = 56{\cdot}9$ pf., and $k' =$ selling price, reckoning 10 per cent. profit on the current supplied, is given by $k' = \frac{35{,}600 \times 140}{115{,}000} + 1{\cdot}1 \times 13{\cdot}53 = 58{\cdot}2$ pf. A number of other examples are given in the original paper. C. K. F

1200. *Regulation of Potentials to Earth of Direct-Current Mains.* **A. Russell.** (Inst. Elect. Engin., Journ. 30. pp. 326–344, Feb., 1901.)—In the case of three-wire distributing networks, the potential of the outer above that of the earth is generally much higher than the difference of potential between adjacent mains. When, therefore—as is almost invariably the case nowadays—the difference of potential between the outers exceeds 250 volts, it becomes necessary to adopt means for preventing the potential from earth of any main from rising above this limit. The author considers how the potentials depend on the fault resistances of the mains, and what methods should be adopted for regulating them. He gives the following elegant graphical construction. Take a straight line, and choose three points in it, P, M, and N, making PM = MN = p.d. between adjacent mains. Let f_1, f_2, and f_3 stand for the fault resistances of the positive, middle, and negative mains respectively. Imagine masses $\frac{1}{f_1}$, $\frac{1}{f_2}$, and $\frac{1}{f_3}$, placed at P, M, and N respectively. Find the point G in the straight line, which is the centre of gravity of these masses. Then PG, MG, and NG give the potentials from earth of the three mains respectively. The author next considers the following methods of keeping down the potential of the positive outer: (1) Earthing the positive outer through a resistance; (2) earthing the middle main through a resistance; (3) earthing the middle main through a battery whose positive is earthed. The earth connection should be removable, so as to allow of the measurement of the insulation resistance of the network. The author deduces expressions for the maximum value of the leakage currents when the middle wire is earthed through a known resistance, and determines the limits between which the leakage watts must lie. A. H.

1201. *Electric Regulations in Various Countries.* **L. Gerard.** (Soc. Belge Élect., Bull. 17. pp. 495–503; Discussion, pp. 503–505, 1900.)—The war between telephone and telegraph interests and traction and lighting interests would have been less bitter if the question as to payment of costs had been definitely decided. In France the administration imposes strict rules, and makes private companies double their telephone lines, &c., at their own expense. In Germany there is no law, and each case is considered on its merits. In Switzerland a very practical law has been passed decreeing the proportions in which costs are to be borne. Telephone lines are doubled at the sole cost of the State.

The minimum distance permissible between a telephone line and a parallel power or lighting line is 2 metres in France, 20 metres in Germany. Two metres is evidently too small in the case of polyphase currents. Lines above 1,000 volts are required to have guard wires underneath in Germany and France, but in Switzerland there is no rule. In Germany the smallest permissible conductor is 10 sq. mm.; in Switzerland it is 22 sq. mm. In Switzerland spans may not exceed 45 metres; in Germany no limit is given.

In the three-phase tramways at Lugano the third conductor was originally the uninsulated rail, but this caused much trouble with the telephone and telegraph wires. The third wire is now insulated, and the trouble is removed.

E. H. C.-H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1202. *The Central London Railway.* (Electrician, 45. pp. 210–212; 276–280; 356–357; 431–433; 554–557; 730–732; 822–826, 1900; 46. pp. 538–541, Feb. 1, and 982–986, April 12, 1901.)—This is a deep-level twin-tunnel railway running between the Bank of England and Shepherd's Bush, 5¾ miles, 13 stations, with a 2½-minute service. The power-house is at Shepherd's Bush, with sub-stations at Notting Hill Gate, Marble Arch, and Post Office. The boiler-room contains 16 Babcock and Wilcox boilers, each rated at 12,000 lbs. of steam per hour at 160 lbs. per square inch, with hot feed from Green's economisers. There are four economisers, each consisting of 768 tubes, with electrically driven scraping gear. There are two chimneys, each 250 feet high by 10 feet internal diameter. The coal conveyor by C. W. Hunt & Co. consists of 200 buckets, each having a maximum capacity of 140 lbs., with a speed of 40 feet per minute. Of the 200 buckets only 20 are at any time being lifted, the others moving along the top of boilers, down the far end, and returning under the boiler-gangway. The conveyor will fill the 1,000-ton bunkers in about seven hours, and this is sufficient for a week's running. The coal descends by gravity through shoots to the mechanical stoker hoppers, which are regulated by a hand feed. Each engine is provided with a separate condenser of the Allis jet type, capable of dealing with 26,000 lbs. of steam per hour normally, or 30,000 if required. The pumps are double acting, 28 inches diameter by 24 inches stroke, and pump water from the hot well to the top of the Barnard cooling towers. There is also an auxiliary condensing plant, which takes the steam from the exciting and lighting sets, consisting of a Wheeler surface condenser of 1,900 square feet cooling surface. The engine-room contains six main generating sets, four exciter sets, and two lighting sets. The main engines are coupled to three-phase generators giving 850 kw., at 5,000 volts, 25 periods, and 94 revolutions. The engines are cross-compound Allis type, with Reynolds Corliss gears. The cylinders are 24 inches and 46 inches by 48 inches. The flywheel weighs 50 tons, and is built in eight sections. The armature, 144 inches in internal diameter, has 32 coils per phase, wound in 192 slots. The alternator has a revolving field with 32 laminated poles. Each coil has an entire slot devoted to it, and the winding of each phase is distributed into two slots per pole, this arrangement lessening the reactance of the armature. The weights are: revolving field with spider, 34,000 lbs.; complete armature, 48,000 lbs., of which the stampings account for 4,500 lbs. The excitation is at 110 volts, and the power required is 13¾ kw. The inductions are as follows: pole faces, 91,100; yoke, 54,700; and core, 50,200, c.g.s. lines. Ten sets of curves are given, showing the results of tests. The exciter sets have Allis engines and Westinghouse six-pole dynamos, and the lighting sets Belliss engines and Westinghouse dynamos. A full description of the main switchboard is given; the high-tension switches are of the Parshall aluminium double break type; the measuring instruments are of the Hartmann and Braun hot wire pattern. Each feeder panel has a bus-bar transformer ammeter in each of the three phases, also a Holden integrating wattmeter and a Thomson recording wattmeter. There are four independent feeders from the power-house, which carry current at 5,000 volts. They are three-core, paper-insulated, and lead-covered, tested to 15,000 volts, and also to 10,000 volts for one hour, firstly between the different cores, and subsequently from the cores to earth. The leading particulars of the cables are—

	0·1875 sq. inch Core.	0·125 sq. inch Core.
Lbs. copper per cable per 1,000 feet length	2,140	1,425
Lbs. insulation per cable per 1,000 feet length......	1,090	995
Lbs. lead per cable per 1,000 feet length	3,870	3,480
Lbs. weight complete cable per 1,000 feet length	7,100	5,900
Lbs. weight complete cable per cubic inch	0·166	0·165
Average specific gravity complete cable	4·6	4·6
Outside diameter in inches	2·125	1·94

Total weight of copper in all high-pressure cables	78·4 tons
Total length of all high-pressure cables................	19·6 miles
Tested capacity per mile :—	
Between one core and the other two cores and sheathing	0·38 microfarads
Between one core and the other two cores alone	0·32 „
Between one core and one other core	0·23 „

Each substation is provided with seven 300-kw. transformers, two 900-kw. rotary converters, two 6-h.p. blower sets, and a switchboard for controlling the three-phase and continuous-current connections. The primaries of the transformers are connected in delta, the core is built up of plates 0·014 inch thick, each sheet being japanned separately to reduce eddy currents to a minimum. Ventilating ducts are left between the laminations at intervals of a few inches, and air is drawn through the core and coils by means of the blowers. The case of each transformer is connected through the base to a common air chamber, and the required ventilation is regulated by dampers. Five drawings and five sets of curves are given, showing the performance of the transformers ; the ageing curve shows a practically constant core loss of 140 watts for 1,300 hours.

A description is given of the substation switchboard, and the construction of the 900 kw. three-phase rotary converters. The leading particulars of the latter are :—

Number of poles	12.
Revolutions per minute	250.
Cycles per second............................	25.
Voltage on commutator	500.
Voltage at collector rings	305.
Armature core	84 in. diameter by 15 in. long.
Shunt winding	912 turns of No. 11 B & S per spool.
Series winding	8 copper strips 2·5 × 0·075 in. in parallel ; 2¼ turns per spool.
Poles..	Laminated sheet steel 12 in. square.
Yoke	Mild cast steel, 123 in. outside diameter by 22 in. long.
Armature core	Laminated iron stampings, 0·014 in. thick.
Length of pole arc	15⅞ in.

Magnetic density in poles	95,000 lines per sq. inch.
„ „ yoke	48,000 „ „
„ „ armature teeth	128,000 „ „
„ „ core below teeth	51,000 „ „
Armature winding	Multiple circuit drum.
Number of commutator segments	576.
Number of slots	288.
Size of slot	1·25 in. deep by 0·44 in. wide.
Number of conductors per slot	4.
Size of each conductor	0·4 in. by 0·125 in. = 0·05 sq. in.
Number of parallel paths through armature	12.
Number of turns in series between brushes	48.
Total cross-section of the twelve paths	0·6 sq. in.
Current density	2,400 amps. per sq. in.
Commutator	54 in. dia. by 15 in., useful length.
Commutator brushes	Carbon, 12 sets of 8 each, size ½ × ¾ in.
Number of tappings for three-phase currents	18, or 3 per pair of poles.
Collector, each ring	24 in. dia. by 3½ in. wide.
Collector brushes	Copper gauze, 8 to each ring.
Weight of armature, commutator, collector, and shaft	24,800 lbs.
Weight of magnet frame, poles, and spools	19,550 lbs.
Weight of collector, brackets, brush gear, &c.	4,000 lbs.

For surface tracks the ordinary type of bull-headed rail is used, but in the tunnel the rail is bridge section. The conductor rail is riveted channel steel, of a total length of 14·7 miles, and is supported by porcelain insulators placed 7½ feet apart. The conductor rail is quadruply bonded with crown bonds, providing an aggregate copper section of 0·62 square inch, whilst the track rails have double bonds one on each side.

Throughout the railway, the stations are superelevated so that on leaving any station the trains start on a down gradient. This has the effect of diminishing the current on starting, whilst on approaching a station the short piece of stiff gradient diminishes the amount of braking force necessary to stop the train. It is said that this method of working has reduced the locomotive expenses by 30 per cent.

The concluding article of the series deals with the locomotives, motors, controllers and locomotive tests.

The motors, of 117 h.p. each, are series wound with the armature built up on a brass sleeve into which the axle is forced. The carcase is cast steel with four laminated poles bolted to it. Two of the coils are large and two small, the large coils being placed horizontally. The windings, with asbestos insulation, are :—

Two large magnet coils: 76 turns of strip copper, 2·12 in. × 0·11 in.; current density, 1,000 amps. per sq. in.

Two small magnet coils: 15 turns of strip copper, 0·875 in. × 0·22 in.; current density, 820 amps. per sq. in.

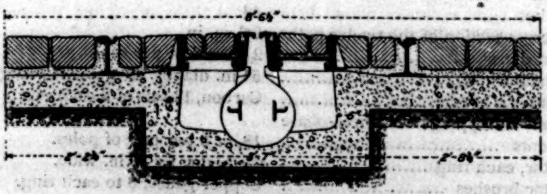
Armature: 61 slots, each 1·73 in. × 0·52 in., with single circuit series-drum winding. Conductors, 0·6 in. × 0·1 in., six per slot, or 188 armature turns in all; current density, 2,100 amps. per sq. in.

Magnetic density: Armature teeth at full load, 127,000 lines per square inch.

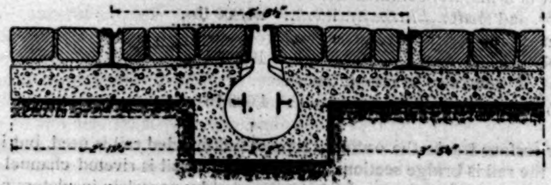
The commutator is 19 in. in diameter and 8 in. long, with 188 segments, one per turn. There are two sets of carbon brushes, with four in each set.

E. K. S.

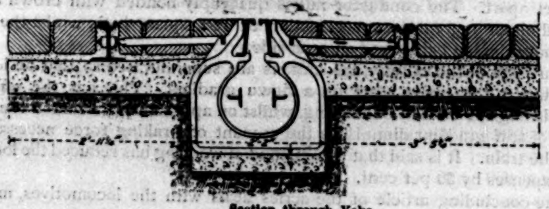
1203. *Electric Conduit for the London County Council.* (Electrician, 46. pp. 651–654, Feb. 22, 1901.)—The figures show the conduit to be used on the routes between Westminster Bridge and Tooting, Kennington Gate and Blackfriars Road, St. George's Circus and Waterloo Road. Continuous current at 500 volts will be supplied from a main generating station and one substation. Double-decked bogie cars will be used, seating 64 to 70, and the speed within a 4-mile radius of Charing Cross will be 10 miles per hour. There will be double track throughout, with 4 ft. 8½ in. gauge and 102-lb. girder rails. The slot will be formed with two Z-section rails, 50 lb. per yard, with a drip lip along the inner edge of slot. The width across the two rails will be 4½ inches, and these will be bolted to the yoke jaws and further fixed by wooden wedges, the width of slot being ¾ inch. The two conductors will be soft steel tees, 28 lbs. per yard, supported on double-petticoated brown insulators at 15 feet intervals, the insulators being placed midway between yokes



Section through Insulator Pit and Road Box.



Section through Concrete Tube.



Section through Yoke.

on cast-iron stems cemented into the concrete. The cast-iron yokes are spaced 5 feet apart, the depth from the top of the slot rail to the bottom of conduit tube being 1 ft. 9½ in., and to base of yoke, where it bears on concrete, 2 ft. 1½ in. The greatest width of yoke is 26 inches and the section at the bottom is I-shaped, 4 inches high, 8 inches wide on the top, and 4½ inches wide on the base.

The article severely criticises the design of yoke. Experience has shown the great importance of having the slot strong to resist lateral pressure, and with this object the yokes have usually been extended out to the rails. In the L.C.C. conduit the depth of yoke from the bottom of the tube to bottom of the casting is only 4 inches, as against 7½ inches in the well-tried Westinghouse design. Wood pavement will not be allowed between track rails on account of expansion when wet. The only advantage of a small yoke is less excavation; but as track rails are being relaid at the same time, this saving is not considerable. The clearance between the conductor rail and the bottom of concrete tube in the L.C.C. design is hardly sufficient to prevent trouble from dirt or from wet-paper when cleaning out the tube. In the earliest electric conduits, the suggested pedestal-supported insulators were tried, but were abandoned in favour of suspended insulators. The use of wooden wedges is criticised on the score of rotting and yielding under heavy traffic. Rust and vibration will gradually deteriorate any yokes, and ample margin of strength is therefore necessary. E. H. C.-H.

1204. *Northwich Electricity Works.* (Elect. Rev. 48. pp. 197–201, Feb. 1, 1901.)—This station is worked on the direct current system, and is interesting on account of the fact that Mond producer gas is used to provide the motive power. The works are situated on a piece of ground belonging to Brunner, Mond & Co., about 1,000 yards from the centre of the town. This site was chosen in view of the fact that the local gas company have a monopoly of the right to supply gas in the town, and it was thought that by placing the works on the site chosen, litigation might be avoided. Mond producer gas is supplied by Brunner Mond to the electric light company through a 12-inch cast-iron pipe which leads to a gas-holder of 2,000 cubic feet capacity. The price charged for the gas is 2d. per 1,000 cubic feet. The Mond gas is said to be remarkably clean: the sawdust scrubber requires cleansing only once a year, and it is said that although engines have been running as long as three years, not one of the pistons has ever been taken out of the cylinder. The main gas engines are by Crossley, running at 210 r.p.m.; the flywheels weigh 8 tons, and are 8 feet in diameter. The larger dynamos are of 60-kw. capacity, by Laurence, Scott & Co., and give 125 amperes at 480 volts, being driven by belting at 600 r.p.m. There is also a set of Chloride cells, 256 in all, having a discharge capacity of 200 amp.-hours. Much trouble has been experienced in connection with the distributing system owing to the frequent subsidences caused by brine pumping. In one case a large joint box completely disappeared, and the hole, down which it disappeared, was afterwards filled up with 600 tons of cinders. The method found most effectual in dealing with these subsidences is to roughly build a second chamber outside each brick junction-box chamber, and to leave a double bend of slack cable in it. Nearly all the consumers are on the further side of the Weaver River, which is crossed by a syphon of 12-inch cast-iron pipes, the joints being made with rubber rings between the flanges. The swing bridges over the Weaver, which have been already described [see Abstract No. 2092 (1900)] are supplied with power by the electric light company. The whole cost of energy for opening and closing the bridge only amounts to 0·83d. at 4d. per unit. The bridge was opened and closed 3,002 times during last year, the total cost of power required being £10 5s. 8d. W. H. S.

1205. *Fulham Electricity Works.* (Electrician, 46. pp. 612–620, Feb. 15, 1901.)—The station is worked on the two-phase alternate current system in conjunction with a dust destructor. It stands on a site which has a river frontage of 370 feet, the total area being 4 acres, though only a small portion of this is occupied by the works at present in existence. The destructors, which are by the Horsfall Company, are placed in two batteries, one at each end of the six boilers, and they occupy with the boilers a space 187 feet long and 87 feet wide. There are at present twelve destructor cells, and there is room for four more; they are capable of destroying 120 tons of refuse in twenty-four hours. The tipping-floor is above the level of the tops of the boilers, and runs from end to end of the building; the roadway leading to the tipping-floor has an incline of 1 in 14. The furnaces of the destructors have each a grate area of 30 square feet, and are fired by means of steam blast, which delivers a mixture of steam and air into the ashpit beneath the grate bars. There are six Babcock and Wilcox boilers, each having a heating surface of 1,284 square feet, and being provided with Vicars stokers; the mechanical stokers are used for firing the boilers in the usual way with coal at times of heavy load. The destructor gases reach a temperature of between 1,800° F. and 2,000° F., and are led to a flue which passes below the ground level, under the boilers, and thence through water-cooled dampers to openings which are arranged behind the bridges of the various boilers. The chimney is 100 feet high, has an internal diameter of 8 feet, and is lined throughout with firebrick. The main steam-ring has a diameter of 9 inches, and there is also an auxiliary ring-main of 3½ inches diameter, which is used for supplying steam to the smaller engines and to the feed-pumps. The exhaust steam from the smaller engines is led to a Royle feed-water heater; the larger engines are worked condensing. The water for boiler-feed is obtained from an artesian well, having a bore of 9½ inches. There is an underground storage-tank, having a capacity of 35,000 gallons, and this is connected both to the well and the town mains. The water, which comes from the chalk, is softened by the Atkins process, which is described at length. The engine-room is 110 feet long and 42 feet wide. The steam-pipes are placed, as far as possible, below the floor level. The three two-phase alternators run at 93·7 r.p.m., being of the flywheel type. The Corliss engines are by Musgrave; the alternators are of the Oerlikon design, and were built by the General Electric Company at Manchester. These generators give 300 kw. each, at a voltage between 2,800 and 3,000, the frequency being 50. There are also three direct-current machines, which are used for exciting the alternators and for supplying light and power in the station itself. They are direct-coupled sets, giving 60 kw. at 460 r.p.m.; the engines were built by Musgrave, and the dynamos by the General Electric Company. There are also three Ferranti rectifiers, capable of supplying 50 arc lamps each, though at present there are only two arc-light circuits, having 43 lamps on each. The condensers are of the ejector type, by Koerting, and give a vacuum at full load of 24 inches of mercury. They are supplied with water from the river. This is drawn from a sump composed of piles on the foreshore; but in order to obtain water at all states of the tide, pipes are run from this sump into the river for a distance of 170 feet, and these terminate in a second sump which is always submerged. In order to clean the pipes and the intake from the river mud, it is proposed, when necessary, to discharge water from the overhead tank (which is used in connection with the condensing apparatus) through the pipes, and so to effect a clearance. The switchboard is by Ferranti. The two-phase current is distributed at high pressure to five substations, where it is transformed down to a pressure of 200 volts, at which pressure it is distributed to consumers. Current of one phase is distributed along one side of the street, and of the other phase on the opposite side. In the case of motors, a service line will be run across the street, and both phases brought in. The substations each contain two transformers of 50-kw. capacity. The article contains drawings showing the general arrangement of the station, the details of the water-softening plant, and the general design of the Oerlikon generators. In addition to these, there are several process blocks. W. H. S.

1206. *Transmission at 40,000 Volts (Telluride).* **J. R. Cravath.** (Elect. World and Engineer, 37. p. 307, Feb. 23, 1901.)—The Telluride Power Company of Utah have 105 miles of line completely encircling Lake Utah. The transformers are Y-connected and the neutral points grounded. They are oil insulated. The line insulators are triple-petticoat glass 7 inches in diameter, the wires being tied into a groove on the side. The wires take the corners of an equilateral triangle of 64-inch side; the top wire is on a pin on the top of the pole, the other two are on a 7-foot cross-arm. Telephone wires could not be run on the same pole. The capacity of the 105 miles is such that the apparent volt amperes at the power-house are 750; the ammeter falls as the wattmeter rises. At two-thirds of full load the power-factor is 95 per cent. The 5,000-volt distribution in the town of Provo is by overhead No. 8 B.W.G. iron wires. The pole-lines run down the centre of the streets, the transformers and street lights being hung directly from the cross-arms. M. O'G.

1207. *Wigan Electricity Works.* (Elect. Engin. 27. pp. 150–160, and 164–167, Feb. 1, 1901.)—The station contains four Babcock and Wilcox boilers, each having 3,140 square feet of heating surface, fitted with superheaters and chain grate stokers. The steam-mains are arranged in duplicate, but are not connected in a ring. An elaborate system of coal-conveyors is installed, the arrangements of which are fully described and illustrated by drawings. Water-softening plant, worked on the Archbutt-Deeley system, is used; the water is said to be reduced from 12 degrees of hardness to 4 degrees at a cost for chemicals of ½d. per 1,000 gallons. There is also an economiser, consisting of 512 tubes, the whole being divisible by valves into three independent sections. The engine-room contains four steam dynamos. The two larger sets give 420 amperes at any voltage from 460 to 500 when used on a lighting load, and 300 amperes at any voltage between 500 and 550 when used on a traction load, the speed being 350 r.p.m. The smaller sets are about two-thirds of the size of the larger ones. Koerting ejector condensers are used; those for the larger engines require 22,000 gallons of water per hour, the vacuum obtainable being equal to 24 inches of mercury. The dynamos are run as shunt-wound machines when supplying the lighting-circuits, and as compound-wound when supplying energy to the tramways. There is a battery of E.P.S. accumulators, consisting of 280 cells, each cell containing 15 plates; they are capable of discharging at the rate of 75 amperes for ten hours, or 300 amperes for one hour, the e.m.f. falling to 1·87. The battery is charged by putting the cells across the bus-bars, the number being then reduced until charging takes place. The cells so cut out are charged independently by a small motor-driven dynamo. There are seven balancing machines in all on the lighting system, distribution being effected by the three-wire method; two of these balancers are in the station, and the remaining five are in substations in different parts of the town. Boosters are used for increasing the pressure, at times of heavy load, on those feeders which run to distant parts of the town. For the lighting circuits three concentric feeders are run, each conductor containing ½ square inch of copper; the distributors are triple-concentric, the outers having a sectional area of 0·2 square inch. There are also three tramway feeders, each of 0·3 square inch of sectional area.

The article concludes with a brief description of the tramway work. It also contains several drawings, showing the arrangement of various parts of the power station. W. H. S.

1208. *Accumulator Traction on the Bologna-San Felice Railway.* **Laninc.** (Elettricità, Milan, 20. pp. 6–10, Jan. 5, 1901. Paper read before the A.E.I. at Geneva.)—The Bologna-San Felice line is 42¼ kilometres in length, with thirteen intermediate stations; the traffic is very small, consisting on the average of 180 passengers daily, and 40 despatches and consignments of goods. The Società delle Strade Ferrate Meridionali has replaced the ordinary steam service with a service of accumulator cars, by way of an experiment, to ascertain whether electric traction is suitable for a line with restricted traffic. The line has few curves, but many gradients up to 6 °/₀. The cars, by Fratelli Diatto, of Turin, are bogie motor cars, 17·5 metres in length, divided into two classes, seating together 52 passengers, with a central space to contain 2 tons of goods; at each end is a cabin for the driver. A four-pole motor, by Ganz & Co., is mounted on one axle of each truck; each motor weighs 1,800 kilos, complete with gear and suspension, and can exert a tractive effort of 400 kilos at the rim of the 102 cm. wheels, when running at 750 r.p.m. The accumulators are of the Pescetto type, by the Società Cruto, in which the positive plates are covered by a thin sheet of perforated lead. Each shell has eight positive plates, 146 × 210 mm., guaranteed to have a capacity of 9 ampere-hours per kilo, at a normal rate of 4·5 amperes, the maximum discharge being 20 amperes per kilo. The cell-box is of ebonite, and weighs, complete with acid, 21 kilos. Twenty-four cells are contained in a wooden box with external iron frame, lined on the bottom with lead, and on the sides with glass.

Each car contains twelve of these boxes, four, however, being somewhat larger to contain each ten cells for lighting. The capacity of the whole battery is 300 ampere-hours, or 180 kw.-hours at 600 volts. The cells are joined up to a switchboard in the goods van, and are arranged in three batteries, which can be put in series or in parallel by one of the two controller cylinders; the second controller cylinder is an ordinary series-parallel controller for the two motors. There are in all eight different running positions—four with the batteries in series and four in parallel. For ordinary service a Westinghouse compressed air-brake is used, supplied by a motor pump, automatically controlled by a switch, which is opened and closed by the air pressure. In reserve are a hand-brake and the usual electric brake, applied by short-circuiting the motors through a resistance.

Power is taken from the three-phase network of the Società Co-operativa di Elettricità di Bologna, at a pressure of 3,000 volts. Two 80-h.p. three-phase induction motors, by Ganz, take current at this pressure, and drive directly, at 840 r.p.m., two six-pole continuous current machines, also by Ganz, giving a voltage variable between 550 and 750 volts. The batteries are charged in the cars, and each charge takes 2 h. 40 m. One charge is amply sufficient for a go and return journey. The single journey occupies 1 h. 20 m., and a car starts every three hours. Two cars only are in use together, one on the line, while the other is charging ; two other cars are kept in reserve. The following are figures relating to the power taken in normal running, which, however, have been obtained under favourable conditions of weather. At starting, the current taken by the motors in series, while the batteries are in parallel, is 300 amperes. In running at the normal speed of 45 km. per hour with motors and batteries in series, the current varies from 60 to 80 amperes. The consumption per return journey is 120 units, or three watt-hours per ton-kilometre. The total efficiency from the dynamo to the car axles is about 50 per cent. From the motor characteristics it has been calculated that the traction coefficient in running varies from 2·8 to 4·5 kilos per ton, and in starting from 6 to 8 kilos. G. H. B.

1209. *Jacques Cartier Transmission Plant.* (Canad. Elect. News, 10. pp. 1–4, Jan., 1901.)—The station which transmits power to Quebec obtains power from the Jacques Cartier River at the rapids of St. Gabriel, 17 miles from Quebec. The river being divided by an island, two dams were built, one 142 feet and the other 158 feet in length. These raise the level of the river sufficiently to give a level surface for six miles up. At one end of the main dam is a masonry bulkhead, from which two pipes, 13 feet in diameter, lead to the power-house, distant 270 feet. The turbines are driven under a pressure of 17 feet, with a suction-tube of 15 feet.

The power-house contains two 54 in. McCormick turbines of 1,710 h.p. at 150 r.p.m. ; and two 18-in. turbines, running at 350 r.p.m. for the exciters. The large turbines have governors of the Lombard type, which, however, cannot be used owing to the inertia of the water in the long-feed tubes. The exciter turbines have Walsh governors. Two Westinghouse three-phase generators are driven directly by the turbines, and give 750 kw. at 2,000 volts and 60 ∿ . The exciters, also direct connected, are 37·5 kw. 125 volt four-pole machines. There are two sets of step-up transformers, each of three 250-kw. units, of the Westinghouse self-cooling oil-insulated type, raising the voltage from 2,000 to 20,000 volts ; these are delta connected on primary and secondary.

Just outside the city is a transformer substation, with two sets of step-down transformers, each consisting of two 375-kw. units with Scott connection for transforming the 20,000 volt three-phase current to two-phase current at 2,000 volts. A mile distant is the distributing switchboard, provided with Stillwell regulators, boosting 4 per cent. each way.

The transmission line consists of two sets of three No. 4 B & S hard-drawn copper wires, carried on 35-feet poles. Each set is transposed five times, and the telephone line at every second pole. Wurt's lightning arresters are placed at each end. The city is divided into eight districts, each fed by one or more banks of transformers, on a three-wire system, with 108 volts on each side. An entirely separate system supplies current for power at 500 volts. G. H. B.

1210. *Chicago Electricity Works* (*Commonwealth Electric Company*). (West. Electn. 28. pp. 29–33, Jan. 12, 1901.)—The polyphase plant outlined in Abstract No. 2327 (1900) is described in detail. The district to be supplied is over 60 square miles in area. The station is built of brick, and at present contains four Babcock boilers of 500 h.p. each, with chain-grate stokers and superheaters. The coal and ash are handled by conveyors, driven by two three-phase G. E. motors of 30 and 20 h.p., and capable of handling 50 tons per hour. The chimney is 200 feet high, chiefly of steel. The two engines are vertical cross-compound, built by the Southwark Foundry and Machine Company. One has cylinders 15 and 32 inches × 36 inches stroke, the other 23 and 52 inches × 36 inches, and both run at 150 r.p.m. The alternators are of 400 and 1,000 kw. output, by the General Electric Company, with 48-pole revolving fields, and generate three-phase current at 4,150 volts, 60 cycles per second. A special electric governor, controlled from the switchboard when synchronising or dividing the load, is fitted to each engine.

Jet condensers are used, in conjunction with two Worthington cooling towers, working by natural draught. There are three 30-kw. exciters, which also provide power for an electric travelling crane and for charging automobiles.

In order to utilise the existing overhead single-phase feeders, these are connected between the neutral point of the Y-connected armatures of the alternators, and one or other of the three outer terminals, at 2,400 volts, balancing the load as well as possible.

Three-phase feeders at 4,150 volts are led direct to the substations, and to a three-phase motor and lighting system which is being developed. Special care has been taken to render the switchboard absolutely safe to handle. All cables inside the building are paper-insulated and lead-covered. The main transmission line to the present substation is three miles long, and consists of eight No. 2 copper conductors, carried by glass insulators on cedar poles 50 feet long. The substation contains switch gear for eight two-wire single-phase and two four-wire three-phase feeders, without step-down transformers. The distributing feeders are all three-core, paper-insulated and lead-covered, while all distributing cables are single. Provision has been made for adding two 500-h.p. boilers, and two 1,000-kw. generating sets at the power station, which can also be extended to receive six more boilers and four more 1,000-kw. sets. A distributing substation will be erected in South Chicago, nine miles from the power station, in the near future. Numerous illustrations accompany the article. A. H. A.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1211. *Measurement of Tramway Currents in Waterpipes.* **S. Krohn.** (Elektrotechn. Zeitschr. 22. pp. 269–271, March 28, 1901.)—The author was instructed by the Union Electricity Company to examine into the state of affairs in a certain town where it was known that corrosion was taking place, and, if possible, to suggest a remedy. His method of examination was as follows. There was a small truck on which was mounted a cable drum, the latter carrying two cables about 300 yards long, having sectional areas respectively of 4 and 14 square mm. The method of measurement may be explained by the aid of the accompanying diagram. R_1 and R_2 are two gas or water pipes, leading to houses about 250 yards apart: these pipes are connected, as shown, to the main, the currents in which have to be measured. The above-mentioned cables K and K_1 are connected through a voltmeter and ammeter respectively to the pipes R_1 and R_2. When the switch C is open, let the voltmeter reading be V : when the switch is closed, let voltmeter reading be V_1, and ammeter reading be i : then the current flowing in the main gas-pipe is $= i\frac{V}{V - V_1}$, and the resistance of the length of piping is $= \frac{V - V_1}{i}$.

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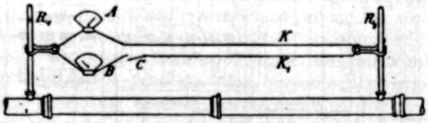
[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

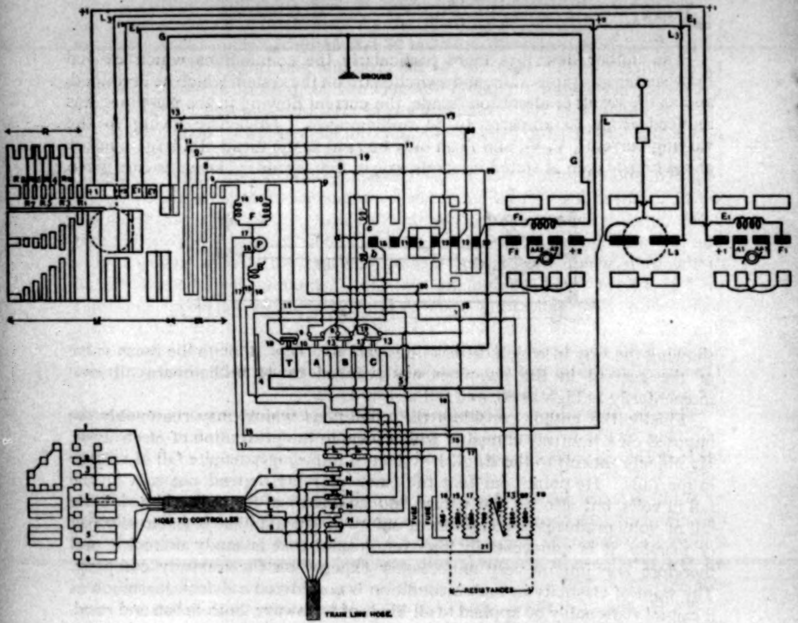
The author describes more particularly the connections which existed between the gas-pipes, rails, and switchboard on the system which he examined, and as the result of alterations made, the current flowing in the gas-pipes was reduced from 80 amperes to 44 milliamperes. Obviously owing to the varying currents, V, V_1, and i can only be read as the mean of a large number of readings, taken at stated intervals, say, of five seconds. Diagrams are given showing the way in which the readings varied. Thus, though the mean value of the current in the gas-pipes was reduced to 44 milliamperes, it rose momentarily as high as 88, and fell as low as 12.



Finally the author considers the conditions which may reasonably be imposed on a tramway company with a view to the prevention of electrolysis. He objects entirely to the English system of imposing a definite fall of voltage in the rails. He points out that the earth currents depend not only on the fall in volts, but also on the nature and condition of the soil. If a definite fall of volts produces a condition of safety in ground that is habitually wet or marshy, it is unnecessarily high for ground that is sandy or rocky, and therefore may impose very unnecessary expense on the tramway company. The want of elasticity in such a condition is considered a defect, inasmuch as it cannot reasonably be applied to all kinds of tramways, both urban and rural. He suggests as an alternative that when the line is in working order, the currents in gas and water pipes should be measured, and at no time should a pipe of 3 cm. diameter carry more than 1 ampere, and so on in proportion. If this or some similar limit were exceeded, the tramway company should be called on to rectify the defect. W. H. S.

1212. *Sprague Multiple-unit System.* **E. Chilton.** (Amer. Electn. 13. pp. 39–41, Jan., 1901.)—The chief practical consideration in designing any multiple-unit system is that the working current be delivered directly to the car that utilises it. Fig. 2 is the car-wiring diagram for the Sprague multiple-unit system. Heavy lines represent main motor circuits ; light lines represent control circuits. M is the main controller drum, *m* the control-circuit part of the main drum, which part is electrically separate from the main motor circuits. P is the armature of the pilot motor which drives the main controller, and which has two field coils, F_{10}, F_{14}, arranged for securing either direction of rotation so as to turn main controller "on" or "off." B′ is a coil in series with pilot motor, arranged to hold off a spring brake when current is passing through motor. The reverser is a drum operated by two solenoids at either end of a band which passes over it : unless current is passing through one of the solenoids a strong spring brings the drum into the central "off" position. T is a device called the "throttle," which makes it impossible to accelerate above a predetermined rate: if the main current rises too high, the throttle opens the pilot-motor circuit and stops the main controller. A, B, C are "relays" which are used to run the main controller respectively to "off" position, last series notch, and last parallel notch. The master controller controls the pilot motor and reverser coils. [See further Abstract No. 395 (1900).]

E. H. C.-H.



CAR WIRING DIAGRAM OF THE SPRAGUE MULTIPLE-UNIT SYSTEM.

1213. *Accumulator Tramway Traction.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 116–127. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 61–81 and 177–181.)—Replies are given by various tramway companies as to the cost of accumulator traction. The report which was presented by **Krüger** in 1898 on the working of the mixed system at Hanover is reprinted. Particulars are also given by **E. E. R. Tratman**, of the accumulator line at Chicago, where the mean cost per car mile in 1898 was 43·75 centimes.

In the report by **Broca** and **Johannet** the whole matter is impartially considered from various points of view, and it is concluded that where the trolley is prohibited, accumulators may sometimes be used to advantage, and that under exceptional conditions they may be even cheaper than the trolley. Success depends upon—(1) centralisation of the batteries, (2) manufacture of strong plates by the tramway company itself, (3) slow charging, (4) suitable placing of the battery on the car, and convenient handling, (5) suitable disposition of terminus and depôts. At St. Denis and Asnières the cost of making plates does not exceed 10 centimes per kg. of lead.

Discussion.—**Boulvin** was of opinion that accumulator traction was generally impracticable, because, in order to avoid breakdown, such a large factor of safety was necessary to meet the exceptional circumstances that must be provided for. The speaker discussed many objections. **Micke** (Berlin) gave some account of the failures of accumulator traction at Berlin, and was strongly opposed to the system. **Krüger** (Hanover) said that tenders were now being adopted for the accumulators at Hanover with good results; in that way the batteries are employed only on those lines where they are required, and inconvenience from acid fumes is avoided. Rapid charging, which is injurious, is avoided. The maintenance and renewals cost only 2 pfennigs in excess of the price of the raw lead per kg. In terms of the car km. this amounts to 0·5–0·6 pfennig per "mixed" car km. (*i.e.*, over that part of the route where the battery is being charged, not over the whole route), or 1·25–1·6 pf. per accumulator car km., including maintenance of all accessories. The generating costs at Hanover in 1899 were 6 pf. per unit; this fell to 5 pf. last year, and to 4·8 pf. last July. The consumption per ton km. is 50 watt-hours. **Koehler** (Berlin) said that the Grande Société de Tramways de Berlin had found the cost of maintenance to be about ten times the figure given by Krüger.

The Congress adopted a resolution to the effect that no important advance had been made in accumulator traction, and that this system should be adopted only in special cases. W. R. C.

1214. *Heating of Tramcars.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 128–131. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 82–86 and 183–192, and 4 plates.)—Report by **C. de Burlet** (Brussels Tramways) on replies received to a question on this subject.

(1) *Heating by Stoves and Movable Appliances.*—This system is the cheapest in first cost and in maintenance, but has many inconveniences. The cost of a stove is about fr. 35, and the cost of fuel is fr. 0·25 per 15 hours. Hot-water receptacles are more costly.

(2) *Heating by Hot Air.*—The Northern Railway of Milan employs a stove supplying a system of pipes with hot air; the first cost is fr. 350 per car, and the running expenses are fr. 0·05 per car-kilometre. The Utrecht tramways employ four gas-stoves per car, consuming 320 litres of gas per hour, and raising the temperature of the car 13° C.

(3) *Heating by Steam or Hot Water.*—The Compagnie Générale des Chemins de Fer Vicinaux Français heat the cars by hot-water circulation; the prime cost is fr. 314 per car, and the running expenses fr. 0·334 per car-day, burning wood charcoal at fr. 51 per ton; the rise of temperature is 24° C. This system gives good and economical results, but has the disadvantage that the water is liable to freeze when the apparatus is not in use.

(4) *Electric Heating.*—The cost of current for the heaters is very heavy. At Hanover it amounts to fr. 2 for 16 hours, the first cost being 40 marks. The Société Nationale des Chemins de Fer Vicinaux employs heaters taking 7 amperes, at a cost of fr. 0·18 per tram-hour of two cars. The Union Elektricitäts Gesellschaft are endeavouring to utilise the heat lost in the

starting and regulating resistances for heating the cars, having two sets of resistances—one in the car for winter use, and one outside for summer.

Discussion on Report.—**Monmerqué** stated that the Compagnie Générale des Omnibus in Paris employs heaters with specially prepared briquettes costing fr. 200 per ton ; the cost is about fr. 1·00 per car per day. **Von Siber** describes the electric heating of the Bielitz-Biala tramcars, the heaters taking 4 to 5 amperes. **Blondin** considered it sufficient to provide foot-warmers, which was done in Paris at a cost of fr. 0·71. G. H. B.

1215. *Falk Rail-Joint.* (Union Int. Permanente de Tramways : Questionnaire, 1900, pp. 110–115. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 56–60, and 171–175.)—Only two tramway companies replied to the questions addressed to them on the subject of the Falk, or cast, rail-joint, namely, the Grosse Berliner Strassenbahn Gesellschaft, and the Compagnie Générale Française de Tramways of Paris. The Tramways Bruxellois gave the replies received by them from various American and French companies to whom they had addressed a similar question.

Report by **Fischer-Dick** (Berlin Tramways) on the replies received.

In America, the Falk joint has been adopted by the Citizen Railway Company over a length of line of 40 kilometres, and by the Memphis Street Railway Company over a similar length of line ; the Chicago City Railway Company has cast 40,000 joints, and the Twin Rapid Transit Company 24,000 joints. In France, there are in Lyons 1,700 Falk joints, in Rouen 1,200, in Havre 6,500, in Marseilles 6,000, in Nice 3,400, and in Paris 2,600. In Berlin, the Tramway Company has cast 7,609 joints. The cost of the joint to the different companies is as follows : At Havre, fr. 20·30 (or, without allowing for royalties and amortisation, fr. 15·60) ; at Lyons, fr. 20·10 ; at Marseilles, fr. 16·50 ; at Paris, fr. 19·89, exclusive of royalties ; at Berlin, the price paid to a contractor was 20 marks, or, including paving, 25 marks ; the cost to the Twin Rapid Transit Company is 2 dollars for 30 kilo rails, exclusive of paving and royalties. The plant, material, and labour required are as follows : At Lyons, 25 moulds and accessories, costing fr. 2,075, exclusive of the furnace ; at Havre, 30 moulds and 60 dogs were sufficient for making 100 joints in a night, the cost of material and plant being fr. 18,500 ; at Marseilles, the cost of 60 moulds and accessories was fr. 17,000 ; the Chicago City Railway Company cast in a night 150 joints for 4½ metre rails, 90 joints for 7 m. rails, and 85 joints for 9 m. rails ; for this was required one furnace, two workshop cars, 6 horses, and 35 men ; inclusive of opening and repaving the track, the time taken was a day and a half ; the Twin Rapid Transit Company employs 50 men to make 75 to 100 joints in a day, including laying the rails ; the Citizen Railway Company states that 65 kilos of metal are required for cast blocks 6 inches long, and 70 kilos for blocks 7 inches long ; the Berlin Tramways state that, allowing 75 kilos per joint, the cost of metal is 400 marks for 50 joints. The breakages of joints are found to be : by the Citizen Railway Company, 1 per cent. ; by the Chicago City Company, ¼ of 1 per cent. ; by the Twin Rapid Transit Company, in asphalt, none, in macadam and pavement, 5 per cent. ; by the Memphis Street Railway Company, ⅓ of 1 per cent. ; at Lyons, ⅓ of 1 per cent. ; at Havre, 4 in 3,800 joints ; at Marseilles, 0·4 of 1 per cent. ; at Paris, 2 in 2,600 joints ; at Berlin, 1¼ per cent. Breakages are attributed to want of care in cutting the rail ends ; cracks form either directly on cooling or during frost. The Twin Rapid Transit Company lays an ordinary fishplate joint every 1,000 feet ; the Compagnie Générale Française, every 250 metres ; at Berlin, the rails are continuous. After the application of the Falk joint, the rails contract considerably; at Berlin, the contraction is 35 to 50 mm. per 100 m. of rail. So great is the force of contraction that no expansion has ever been observed under the hottest sun. The electrical resistance offered by the joint depends largely on the care used in fitting the rail ends; there is, however, no need for bonding the joints. The Falk joint has an advantage over the electrically welded joint, in that it does not heat the rail ends to so high a temperature, and maintains the quality of the metal. All the companies using the joint are unanimous in declaring its superiority over the fishplate joint. G. H. B.

1216. *Tramway Brakes.* (Union Int. Permanente de Tramways: Questionnaire, 1900, p. 138. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 94–104.)—Only four companies replied to the question addressed to them on the subject of brakes, and the information supplied was insufficient to form the basis of a report. The reporter, **Monmerqué,** confines himself therefore to giving particulars of the regulations issued by the Paris authorities, and of the brakes employed by the Compagnie Générale des Omnibus. The regulations decreed by the President of the Republic impose the following conditions. Locomotives must be provided with hand-brakes. The brakes must be sufficiently powerful to stop the locomotive when running at a speed of 20 kilometres per hour on the level on clean and dry rails, in a distance of 20 metres. Every car must also be provided with brakes, which, together with the locomotive brakes, must be sufficiently powerful to stop the whole train in a distance of 20 metres under the same conditions. The Paris Police in July, 1900, increased the severity of these conditions by imposing them on a down gradient of 2 per cent. instead of on the level, and by stipulating that every car have two independent brakes acting on all the axles. The Compagnie Générale des Omnibus employs the following brakes on each motor car: (1) a direct-acting compressed air brake, applicable by the driver; (2) an automatic compressed air brake applicable by driver and conductor; (3) a hand-brake applicable by driver and conductor; (4) a brake applicable by the driver by short-circuiting the motors.

Discussion.—**Von Leber** deprecated the multiplication of brakes, as giving the driver too much to do on an emergency. At Vienna a chain hand-brake is used, provided with a reserve chain, and an electrical short-circuiting brake. **Fromm** gives the results of an investigation made by him on the brakes employed by sixty-three different tramway companies. Thirty-five companies employ the short-circuit brake, eighteen companies electromagnetic brakes, and six employ compressed air brakes; the majority have besides hand-brakes. At Hamburg the following results were obtained: a car with one motor and Union electromagnetic brakes on the motor axle, attached to a trailer with similar brakes, stopped on dry rails in 10–12 metres, on sanded rails in 9½–11½ metres, and on wet rails in 19–26 metres; the cars were running at 22 km. per hour on the level. A motor car with two motors and short-circuit brakes, attached to two trailers, with Union and Schuckert electromagnetic brakes respectively, running under the same conditions, stopped on dry rails in 8½–14 metres, on sanded rails in 5½–12 metres, and on wet rails in 21–38 metres. The same train, but with Schiemann rail-brakes, instead of the short-circuit brake, on the motor car, stopped on dry rails in 6¾–10 metres, on sanded rails in 4½–6 metres, and on wet rails in 14–20½ metres. The investigations led to the following conclusions. (1) Short-circuit brakes give good results, except when they are used on the ordinary service brake. (2) Electromagnetic brakes are to be recommended for heavy cars or on lines with heavy gradients. (3) Compressed air brakes give good results, but their use is too restricted to enable general conclusions to be formed. **Koehler** (Berlin Tramways) spoke on the Sperry electromagnetic brake employed by his company. The braking is found to be rather too sudden, and the motors are kept more continuously at work. G. H. B.

1217. *Central Station Equipment for Tramways.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 81–93. Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 45–49 and 151–158.)—Report of **Thonet** and **d'Hoop** on the sixteen replies received from various companies to a question put by the Society on the above subject. *Capacity of station.*—The replies refer to stations varying in capacity from 200 kw. to 5,000 kw. at Marseilles, or 13,500 kw. in the three Berlin stations. The capacity is in general double the maximum output demanded. The average power required on days of maximum traffic is about one-third greater than, and on some tramways double, that in normal conditions of traffic. The ratio of the mean to the maximum output is generally from 1 : 1·5 to 1 : 1·7, rarely 1 : 2. *Dynamos* are always direct driven, except in the case of machines of less than 100 kw. They are generally compound-wound, but sometimes shunt-wound, in view of a possible installation of accumulators. They are capable of withstanding an overcharge of 25 per cent. for 1½ hours, and sometimes of 40 per cent. for one hour, with a rise of temperature of not more than 60° C. Seven companies of the sixteen employ accumulators. *Steam engines* are generally compound, except in France, where many single-cylinder Farcot engines are in use up to a power of 1,000 h.p. The valve-gears used are Corliss and Rider. The speed varies in France from 65 to 120 r.p.m., and in Belgium and Germany from 90 to 150 r.p.m. The engines are generally horizontal, using jet condensers, except in Germany and in certain stations where want of room has dictated the use of vertical engines and surface condensers. The pressure used is for compound engines from 8 to 10 kilos per sq. cm., and for single-cylinder engines from 6 to 7·5 kilos. *Boilers.*—The boilers in general use are, in Germany, Gehre, Steinmüller, Cornwall, and Babcock and Wilcox; in France and Belgium, Piedbœuf, Babcock and Willcox, and Denayer. The heating surface varies from 150 to 250 sq. metres, and the grate surface from 2·5 to 6·0 sq. metres. In general, one quarter of the total number of boilers are in reserve. The Compagnie Générale Française des Tramways à Nancy employ in their boilers the "Émulseur Dubian," an arrangement designed to promote circulation of the water. Tests have shown an economy of from 15 per cent. to 50 per cent. resulting from its use.

The Orleans Tramway Company employ Crossley gas engines of 165 h.p. each, with Fichet and Heurtey plant for producer gas. A battery of accumulators is installed with booster for charging. The mean consumption of fuel during a year is 750 grammes of anthracite per kw.-hour, or 450 grammes per car-kilometre, corresponding to 600 grammes per b.h.p.-hour. *Mechanical stokers* are in use only at Havre, where the Godillot type is installed. Boilers are cleaned generally every two or three months. Only a few companies employ *smoke-consumers;* at Marseilles, smoke-consumers by the Société Alsacienne of Mulhouse are in use, and give satisfactory results. *Stacks* have in general a height of over 40 metres, with a diameter of about 3 metres at the base and 2 at the top. *Feed-water heaters.*—In the majority of cases the feed-water is heated only by the exhaust from the feed-pumps, which produces a rise of temperature of about 45° C. Only one installation uses the exhaust from the main engines for this purpose instead of condensing it. In three installations, at Havre, Marseilles, and Nancy, Green's economisers are used. *Superheaters* are employed by four companies in nine stations; in each case the superheaters are in the boilers, the superheat varying from 40° to 115° C. Only in one case was an estimate given of the economy resulting from their use, the figure given being 3 per cent. *Apparatus for cooling the condenser water* are employed in most stations; they consist either of cooling towers or, more especially in France, spray-coolers. *Feed-water purifiers* are used at Havre and Marseilles only. The Société Nationale des Chemins de Fer Vicinaux inject petroleum to prevent incrustation. *Consumption of fuel in evaporation.*—The best results, taking into account the calorific value of the fuel, are obtained with fire-tube boilers. *Consumption of steam* varies from 5·7 to 8·7 kilos per i.h.p., putting aside the single case in which condensers are not employed. The installations making use of superheaters show the highest consumptions. The engines with Corliss gear give better results than slide-valve engines. At Havre and Nancy, with single-cylinder machines, the consumption is only 6·25 and 6·90 kilos per i.h.p. *Consumption of oil.*—The figures given relative to the consumption of oil differ enormously; they vary from 1 to 8 for cylinders and from 1 to 20 for bearings. At Brussels the oil is extracted from dirty waste by a centrifugal machine, with very economical results.

The author concludes with the following recommendations:—

In large stations the engines should be compound-condensing and direct-driving.

In medium-sized installations it is generally of advantage to employ buffer batteries.

In small stations the use of gas engines and Dowson gas gives very good results.

Discussion on the report.—**Monmerqué** proposed to modify Thouet and Hoop's first recommendation by adding the alternative of triple-expansion engines, on the ground of their economy and of the better regulation they give. **Baumgardt** recommends the use of buffer batteries, even in the case of large installations. **Thonet,** in reply, did not agree that any economy resulted from the use of batteries in large installations; their chief advantage is in equalising the load on the generators, and in large installations the variations of load are less than in small ones. He agreed to Monmerqué's addition.

The conclusions of the report were agreed to by the Congress. G. H. B.

1218. *Acceleration of Electric Cars.* **G. H. Morse.** (Street Railway Journ. 17. pp. 131–133, Feb., 1901.)—The problem of the best acceleration to use in starting cars is one of pressing importance. If the stations be far apart and the speed moderate, it will be economical to employ motors having little reserve capacity, and to use very little regulating resistance for starting the cars. When stops are frequent and high speed is necessary the conditions of economy are entirely different. We may use more powerful motors, but a limit is soon reached, as the acceleration only increases very slowly with the size of the motors. The best means to accomplish a rapid start is to keep the acceleration constant until the required speed is reached. In order to do this we must use large regulating resistances and gradually cut them out as the currents fall below their maximum safe values. In this case the velocity curve is practically a straight line through the origin, which finally bends with rather a sharp curve as the maximum speed is approached. The author gives a graphical solution of the problem of finding the various combinations of the commercial motors to be employed on a given electric car so that its actual velocity at any instant may agree very closely with any desired velocity curve. The final result shows whether the proposed set of motors is suitable, and it gives the required controlling resistances and the efficiency of the various combinations at each stage of the start when the car accelerates according to a definite economic law. The author finds that practical velocity curves can be closely imitated by a parabola, or for very high speeds by a straight line the end of which is capped off with a parabola. A concrete case is worked out. A train weighing 132 tons is to start with a given acceleration curve on an incline of 0·5 per cent. so that it gets up a speed of 24 miles in 30 seconds. The type of motor considered is the G.E. 2,000, and curves are drawn showing the kilowatts absorbed by this motor from the line at 500 and at 250 volts for given horizontal efforts. By combining the various curves the author shows how to calculate the controlling resistances required at each instant during the start. A. R.

1219. *Automatic Electric Block-signals for Railways.* **L. Kohlfürst.** (Elektrotechn. Zeitschr. 21. pp. 929–932; 950–952; 980–982; 998–1001; and 1017–1019, 1900.)—In these articles, the most important systems of automatic electric block-signalling are fully described. The first given is that of Joseph Sacek, which is designed to work with steam locomotives. On the locomotive is mounted a small dynamo or an accumulator, one terminal of which is earthed and the other is connected directly to a brush on one side of the locomotive, and also through the coils of a Hughes electromagnet to a brush on the other side of the locomotive, this electromagnet being adapted to actuate either a steam whistle or a brake-releasing device. The passage of the train over the rails completes local battery circuits including relays, which block the line for two sections of line in the rear, so that a following train fitted with the apparatus above-mentioned will be warned that the line is not clear. A system of mercury contacts acting by the compression of air in a closed vessel under the rails on the passage of a train is also described for use in connection with this system.

The Timmis-Lavezzari system is then described, for a description of which see Abstract No. 1738 (1900).

Ceradini's system is next described. This system comprises blocking signals on both the line and locomotive. The signals on the locomotive consists of two Lartigue steam whistles, one of which is sounded by an electromagnetically operated valve when the train enters a block-section, and the other is similarly sounded if the section is clear, this being effected by a battery on the train and fixed contacts on the track. The line is divided up into sections, in each of which is an instrument comprising two electromagnets. These electromagnets oscillate a balance-beam whereby a signal disc is rotated and contacts are made or broken, controlling the sounding of the "line clear" whistle on the locomotive.

The Krizik system is also described, for which see Abstract No. 2091 (1900).

The Siemens and Halske partly automatic system comprises an electromagnetically controlled pawl whereby the signal is held in the "line clear" position against the action of gravity, this pawl being tripped by the action of a current in a circuit completed by the passage of a train over the section, so as to allow the signal to move into the "danger" position. The signal is returned to the "line clear" position by hand.

Basanta's system, in addition to giving audible signals, permits telephonic communication between the carriages, and between the train and the stations.

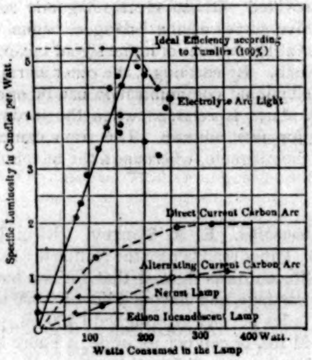
The danger signals are given exclusively on the locomotive on which is arranged an alternate-current dynamo giving from 10 to 40 volts. From station to station insulated conductors, l, are arranged parallel to the rails; these conductors do not, however, meet, but are overlapped by separated insulated conductors, l_2, at the stations, whilst two short sections of insulated conductor, l_1, are arranged respectively about 500 metres in front of and behind each of the points, *e.g.*, of the station-loop of a single line railway. The locomotive bears three brushes, each adapted to engage respectively with one of these series of conductors, the locomotive itself and the rails serving as a common return. The locomotive is also provided with a telephone set, a magneto-machine, and two alarms, each giving notes of distinct character and earthed through the dynamo; the stations are fitted with one alarm, switches, a telephone set, and two rheostats; and the sections l_1 to an alarm operated by clockwork and provided with an electromagnetic release. One of the alarms on the locomotive serves as the "danger" signal, and is operated by depressing keys either at the stations or in the signal-boxes, these keys putting the conductors l_2 to earth. By earthing l, the other alarm on the locomotive is rung, after which telephonic communication can be opened with the train, whilst the clockwork alarm is released when the locomotive passes each section l, and rings for five minutes. The train can always ring up the stations by means of the magneto, whereupon the telephone can be switched into circuit. C. K. F.

1220. *Electric Automobiles.* **E. A. Sperry.** (Elect. Rev. N.Y. 36. p. 596 and pp. 608–610, 1900. Paper read before the National Electric Light Association, May 24, 1900.)—Recent tests showed that for two batteries of the same capacity on the same carriage, and having a life of 3,000 to 4,000 ton-miles, a Planté battery ran 20 miles per charge, weighed 1,260 lbs., gave 5·25 watt-hours per lb. and required 21 lbs. of cell per ton-mile; a Faure battery ran 29 miles per charge, weighed 980 lbs., gave 6·5 watt-hours per lb., and required 30 lbs. of cell per ton-mile. The remarkable advantage of halving the weight of batteries for the same cost and output is pointed out. M. O'G.

ELECTRIC LAMPS AND LIGHTING.

1221. *Artificial Light of the Character of Daylight.* **A. Dufton** and **W. M. Gardner.** (Brit. Assoc. Report, 1900, pp. 631–632.)—Starting with the electric arc light as being nearest daylight in character, the authors have attempted to imitate by direct absorption the effect produced by scattering in the atmosphere. The light of an arc lamp consists of two distinct parts: (1) The light from the glowing carbons; (2) the light of the arc itself, characterised by its richness in violet rays. In lamps of the enclosed arc type the length of arc is increased, and consequently such lamps give a light richer in violet rays. Although arc lights vary somewhat in the proportion of violet light, they all agree in being richer than daylight in the amount of red, orange, and yellow rays, compared with the amount of green and blue. Owing to the peculiar transparency of colours to red lights already known, it is of primary importance that the proportion of red light should be carefully adjusted. Small variations in the amount of violet light are of minor importance, owing to the eye being less sensitive to such rays, and also because in mixing colours there is not the same tendency to develop a band of violet as occurs in the red, since yellow colours generally have complete absorption in the violet. The required absorption of the less refrangible rays can be effected by means of blue cupric salts. A solution of copper sulphate shows strong absorption at the extreme red of the spectrum, the absorption extending with diminishing intensity into the green. For practical purposes the light from the arc is modified by passage through pale blue glass coloured by means of copper. This coloured glass may conveniently take the form of a globe replacing the ordinary globe of the arc light. E. E. F.

1222. *A New Form of Arc Light.* **E. Rasch.** (Elektrotechn. Zeitschr. **22.** pp. 155–157, Feb. 14, 1901.)—This article deals with an invention which is embodied in the German patent No. 117214 of March 18, 1899. Electrodes are made of magnesia, lime, thoria, zirconia, or other refractory substance, and the light given out by the arc which passes between these electrodes is said to be produced more economically than is the case with the light of the ordinary arc lamp. The electrodes require to be heated before the light can be produced, and this heating is effected by a subsidiary arc, which passes between two good conductors. No details of the mechanism are given. The light emitted by magnesia or zirconia electrodes is brilliantly white, as compared with the violet light of the ordinary carbon arc, while electrodes of fluorspar, chromic oxide, and nickel oxide give a distinctly yellow light. The author distinguishes between "soft" and "hard" electrodes. Under the former head are included substances which have a low conductivity without preliminary heating and can be made to conduct by the application of a sufficient voltage. They make bad electrodes for the purposes of the arc, seeing that ellipsoidal molten "drops" are formed at the tips, and it is impossible without complications to maintain a steady arc. Moreover, with soft electrodes, the voltage does not sensibly increase with the length of arc, and the author states that in order to form a stable and economical arc, it is necessary that this increase should be very marked. "Hard" electrodes are



therefore much to be preferred; they require considerable heating in order to render them conductors. Photometric tests show that the electrolytic arc light is more economical than anything hitherto known. The author claims that with electrodes of 2·5 mm. diameter, a light of 600 hefner candles can be produced with a consumption of 158 watts, though even this is not the most favourable case quoted. The annexed diagram gives comparative curves, showing the relation between watts and candle-power in the various kinds of lamps. In the ordinary incandescent lamp, the consumption varies from 3 to 4 watts per c.p.; in the Nernst lamp, from 1·5 to 1·6 watts per c.p.; in the alternate current carbon arc lamp, 0·8 watts per c.p.; in the direct current arc lamp, 0·5 watts per c.p.; and in the electrolytic arc lamp, from 0·25 to 0·3 watts per c.p. W. H. S.

REFERENCES.

1223. *Water-Power for Electrical Purposes.* **R. F. Yorke.** (Elect. Rev. 48. pp. 127–130, Jan. 18; Discussion, pp. 170–172, Jan. 25, 1901.)—Paper read before the Glasgow Section of the I.E.E.

1224. *Street Car Building.* **C. H. Davis.** (Street Rly. Journ. 16. pp. 143–146; 250–253; 312–319; 377–383; 445–450; 513–520; 611–616; 703–707; 827–833; and p. 1007, 1900; 17. pp. 59–63, Jan., 1901.)—Articles on construction, including drawings.

1225. *Central Station Costs.* (Electrician, 46. pp. 382–388, Jan 4, 1901.)—Tables and diagrams are given showing working expenses, &c., in several stations, more particularly in 1898 and 1899.

1226. *Electric Train-Lighting in Railway Carriages.* **O. May.** (Elektrotechn. Zeitschr. 22. pp. 29–30, Jan. 3, 1901.)—This is a paper read before the Elektrotechnische Gesellschaft at Frankfort in which the advisability of introducing the electric light in trains is discussed. C. K. F.

1227. *German Tramways.* (Elektrotechn. Zeitschr. 22. pp. 119–135, Feb. 7, 1901.)—Statistics relating to the various electric tramways and railways in Germany.

1228. *French Tramways.* **A. Soulier.** (Ind. Élect. 10. pp. 127–135, March 25, 1901.) Tabulated technical particulars are given, referring to the various electrical railways and tramways in France.

1229. *Electrolysis by Earth Returns at Peoria.* **D. H. Maury** and **A. A. Knudson.** (Eng. News, 45. pp. 66–68, Jan. 24, 1901.)—A reply to criticism of the author's paper [Abstract No. 2518 (1900)] by A. B. Herrick [Abstract No. 581 (1901)], with further photographs of pitted Peoria water-pipes. E. H. C.-H.

1230. *Polyphase Electric Traction.* **I. Galmozzi.** (Écl. Électr. 26. pp. 473–480, March 30, 1901.)—This paper contains a theoretical investigation regarding the fall of potential along the overhead conductors and the rail return of three-phase and two-phase systems of traction. The author deduces approximate formulæ for calculating the drop of potential along the conductors. A. H.

TELEGRAPHY AND TELEPHONY.

1231. *Baudot's Quadruplex on Branch Lines.* **F. Luginbühl.** (Journ. Télégraph. 25. pp. 28–31, Feb., 1901.)—Description, with diagrams, of an installation of a distributor of special construction at a central station by which three other stations radiating from this can interchange communications with the central or with each other. The article does not admit of abbreviation, as it is entirely explanatory of the diagrams by lettering.
E. O. W.

1232. *Giltay's System of Harmonic Telegraphy.* **J. W. Giltay.** (Elektrotechn. Zeitschr. 22. pp. 99–100, Jan. 31, 1901.)—At each of the stations in this system, which are arranged in pairs, for example, there is an induction coil, the primary circuit of which includes a battery and a microphone fitted to a König's resonator in communication with a stopped organ-pipe giving the same note as the resonator and capable of being blown continuously in any suitable manner. The secondary of the induction coil is in the line circuit, and is shunted by a condenser and also by a key which normally short-circuits the secondary. There is also connected in the line circuit, a telephone-receiver which is fitted with a König's resonator tuned to the same note as the microphone-resonator and organ-pipe at the other station of the pair, the receiver-resonator at this latter station being tuned to the same note as the microphone-resonator and organ-pipe of the former station. When the key at either station of the pair is depressed to remove the short-circuit from the corresponding secondary, an alternating current of definite periodicity passes into the line and causes the receiver-resonator at the other station of the pair to resound, the resonators at the remaining stations not being affected since they are tuned to different notes. Signals can be sent by the Morse code. Some experiments are described and diagrams are given of the connections.
C. K. F.

1233. *Explosion of Mines by Wireless Telegraphy.* **A. Breydel.** (Soc. Belge Élect., Bull. 18. pp. 13–15, Jan., 1901.)—An arrangement of the usual form is described, the only peculiarity being that the whole is enclosed in a metal box, having only a small opening at one side to admit the rays from the transmitter. No vertical wire or collector of any kind is used, hence the apparatus is probably very insensitive. The author remarks that tubes containing rarefied gases are more sensitive than metallic coherers to electrical radiations, and may be used with advantage.
J. E.-M.

1234. *A New Photophone.* **E. Ruhmer.** (Elektrotechn. Zeitschr. 22. pp. 196–198, Feb. 28, 1901.)—Basing his experiments on the discoveries and inventions of Graham Bell, Simon, and Duddell, the author describes an ingenious form of photophone in which the transmitter is an electric arc, and the receiver a selenium cell in circuit with a local battery and recording apparatus. It is suggested that such an apparatus could with great ease be fitted on board ship for signalling purposes, the arc of a searchlight being used as transmitter. As the system is telephonic, the messages would only be received by the ship on which the ray of light was directed.
J. E.-M.